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Preliminary Version

Computer Programs for Passive Solar Residential Design

Leslie Jones and Associates

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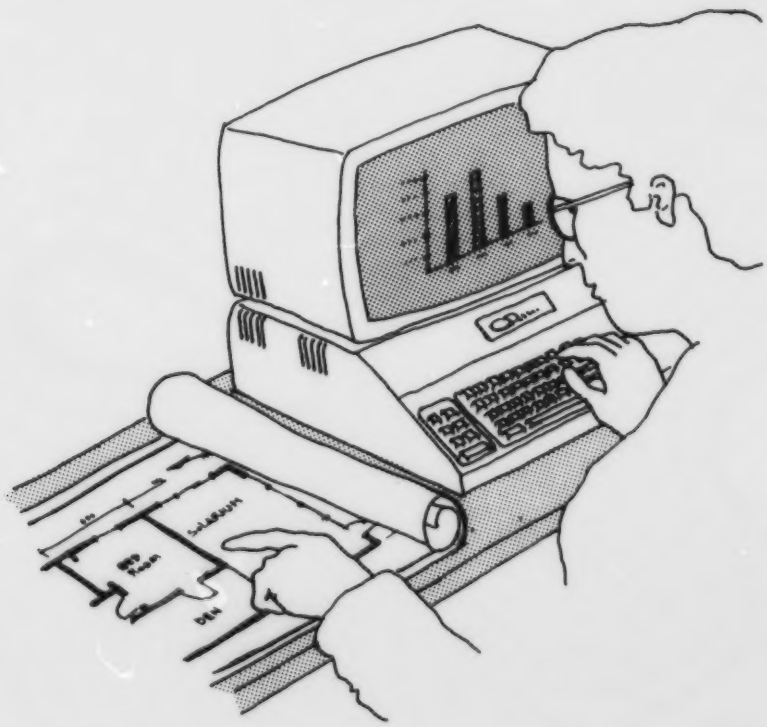

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- NOTICE -

In preparing this publication, we have made every reasonable effort to ensure completeness, accuracy and currentness of information. Because of the rapid changes in software development, some information presented in this publication may be outdated and it is suggested that readers may wish to contact program authors directly to see if 'weaknesses' highlighted in this report have been addressed.

Further, in selecting design methods for evaluation, we apologize to those software developers whom we have inadvertently missed (although over 400 were considered) or whose programs would now meet the criteria that were used for our selection of software to be tested.

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ABSTRACT / RESUME

COMPUTER PROGRAMS FOR PASSIVE SOLAR RESIDENTIAL DESIGN

This publication is intended to provide guidance to designers on the selection of software for the evaluation of passive solar and conservation strategies in single family residential buildings.

A discussion of basic calculation methods is presented along with a review of 'state of the art' energy models, followed by a detailed evaluation and comparison of eight commercially available analysis methods. The methods evaluated range from detailed hourly models to simplified monthly analysis methods.

The evaluation addresses, and information is presented in four areas; 'Scope', 'Accuracy', 'Ease of Use' and 'Cost'. It is felt this information will help a designer identify his priorities so as to enable him to select software that best meet his own particular requirements.

LES LOGICIELS POUR LA CONCEPTION DES MAISONS SOLAIRES PASSIVES

Avec cette publication on veut aider les concepteurs dans la sélection d'un logiciel pour l'évaluation des stratégies de l'utilisation du solaire passif et de l'économic d'énergie dans les maisons unifamiliales.

Sont présentées des méthodes de calcul de base avec une revue des modèles courants de stimulation du rendement énergétique des maisons. Suivant une évaluation et une comparaison des huit méthodes d'analyse disponibles sur le marché. La gamme des méthodes évaluées va des simulations détaillées par heure jusqu'aux simulations par analyse mensuelle.

L'évaluation et l'information sont présentées selong quatre catégories; 'PORTÉE', 'PRÉCISION', 'FACILITÉ À UTILISER', et 'COÛT'. Cette information devrait aider le concepteur dans l'identification de ses priorités pour qu'il puisse sélectionner le meilleur logiciel pour ses besoins particuliers.

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SUMMARY

This document summarises work initiated by the National Research Council of Canada and is aimed at providing guidance on the selection and application of software for the evaluation of passive solar residences.

The project involved:

i) The development of a standard evaluation method that could be consistently applied to currently available tools and to new and enhanced tools as they become available.

ii) The selection and evaluation of a number of design tools using the developed evaluation methodology.

The developed methodology examines four aspects of software quality; scope or range of features capable of being addressed, accuracy, ease of use, and cost.

Technical scope is addressed by providing a list of possible design features that a designer might wish to consider against which the capabilities of each program is documented. Such a presentation is intended to help a designer make sure any programs that he might select are capable of addressing all those design features of interest to him.

Accuracy is addressed in two ways. First, the sensitivity of each program to those parameters that are known to affect energy use was documented. It is suggested that more sensitive programs are potentially most accurate. The second step involved an evaluation of the accuracy of simulation for a range of design features. For those programs capable of generating hourly data (SERI-RES, ENERPASS, CALPAS3) this involved a comparison between calculated results and monitored energy and temperature data from a number of experimental test huts. For those programs not capable of hourly simulation, comparisons were made against annual data prepared for the test huts using the results obtained from the hourly models.

Ease of use was 'evaluated' by considering:

i) the ease of actual data input and output manipulations, i.e. "user-machine dialogue";

ii) the extent of the input data requirements and the time taken to collect and prepare the neces sary data in order to run the program;

iii) where it is generally made available to the user, the structure and readability of the actual program code;

iv) the completeness, clarity, and general ease of use of the documentation;

v) the consistency of calculated results between different users trying the same simulation.

Finally costs for the software were documented for each of the packages tested to enable a user to select a program within his price range. Purchase and user costs, such as royalties, running costs are presented along with estimates of the level of engineering time associated with learning and running the program since these costs are often more significant than actual purchase cost.

The selection of methods for testing was based on the comparison of over 400 analysis tools against what was felt necessary for a thorough thermal analysis of a passive solar residence that could reasonably be carried out by designers. Only five programs ENERPASS, CALPAS3, SERI-RES, SUNCODE and MICROPAS met this this criteria, and of these only three methods, ENERPASS, CALPAS3 and SERI-RES were ultimately tested (MICROPASS and SUNCODE being dropped owing to their respective similarities to CALPAS3 and SERI-RES).

Five other methods, that did not meet all the criteria, were added to the list to be tested. These programs were F-LOAD, SUNPAS (an SLR method), CMHC2, HOTCAN AND CASAMO (a French Language Program).

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The overall evaluation project, for which this document is a partial summary, was reviewed and directed by M. Glover and D. Colley of the Solar Energy Program along with the following members of a steering committee:

- E. Sherman
  - Public Works Canada, Ottawa
- B. Gough
  - Energy Building Group, Ottawa
- G. Allen
  - Allen Drerup White, Ltd., Toronto
- S. Carpenter
  - Enermodal Engineering, Waterloo
- E. Cuplinskas
  - Okins, Leipciger, Cuplinskas, Kaminker & Associates, Toronto
- G. Yuill
  - G.K. Yuill & Associates, Winnipeg
- W. Webster
  - Canada Mortgage & Housing Corp., Ottawa
- S. Barakat & K. Ruberg
  - Division of Building Research, NRCC, Ottawa

We extend our thanks to the above and to the program authors, all of whom gave us their full cooperation.

Our thanks also go to Claude Parisel, Lyse Gelinas and Renee Daoust of the University of Montreal, and to Bruce Gough of the Energy Building Group who contributed in the actual program evaluations. We also thank Neil McEachen and Tony Zimmer of Group 5 Consulting on whose computer and with whose help SERI-RES was run.

FORWARD

While building energy analysis models had existed previously, their development and proliferation was accelerated by the need to respond to the oil crisis of the 1970's with more energy efficient buildings.

Since that time development and use has continued albeit in a somewhat eratic manner; at times energy programs being variously hailed as an essential design tool, or the contrary, a needless and costly burden to design that no one was prepared to pay for.

Since the early days of development there has always been a dilemma concerning the apparently irreconcilable need for accuracy with that of ease of use. This dilemma has not yet been resolved and potential users of design tools should be prepared to address this.

ACCURACY

If we start with the premise that accuracy is essential, otherwise the analysis is pointless, we need to ask ourselves how accurate need the analysis be and whether or not we need "absolute" accuracy or "relative" accuracy. Relative accuracy, i.e. the software correctly predicts trends, can be considered sufficient if one is choosing one strategy over another without regard for capital and life cycle costs. If, however, such considerations are important, absolute accuracy is desirable. Further, it should be realized that in practice perfect simulation will always elude us because of the practicalities associated with the prediction of actual site construction methods, materials and building usage. A designer needs to decide what would be an appropriate level of accuracy given the time he might have to spend on analysis and the degree of economic risk he or his client might be prepared to accept should energy predictions be used as the basis for capital investment.

EASE OF USE

In addition to improving the user machine dialogue, software designers have typically followed either one of the principal directions for making software easier to use.

The first involves using simplified analysis methods whilst the second involves limiting the scope of the analysis; of course both approaches could be followed simultaneously or one may impact on the other, e.g. simple methods may limit the scope. Neither of these steps necessarily compromise the accuracy of all results but the accuracy outside of a certain limited range of applications will definitely be affected. For the user of software it is important to make sure that the software is suitable for the range of design decisions under consideration. This is an important consideration for selecting software. To try to use software for analysis that lie outside a range for which it is suitable or designed for is a very difficult and dangerous practice but unfortunately it is one which is often pursued by analysts, who having once purchased or invested in the learning of an analysis tool, are reluctant to move to other more suitable software. The limited results of the work reported in this document suggest that resorting to tricking a program or relying on intuitive input for some key variables may cause widely differing predicted results between analysts trying to model the same building with so-called simple tools (i.e. the 'simple analysis' tool becomes "more difficult" to use when used beyond its appropriate range of application).

Moving to more rigorous mathematical models and increasing the scope of possible strategies inevitably makes the software more time-consuming and in most cases this can be equated with increasing difficulty of use but with potentially more accurate results over a wider range of design strategies. Again, based on the work reported here and witnessed in other studies, accuracy is not always assured by moving to more rigorous models as the potential for error increases with the need to provide more input information. Typically such models demand that the user have a more thorough understanding of the basic mathematical and engineering principles governing the real world situation.

In a move to simplify input to these detailed programs many variables are often automatically assigned "default values" which will be used in the simulation unless the analyst chooses to input his own information. While the use of default values is a fairly common practice and undoubtedly can speed up input data preparation, the adoption without questioning their suitability can seriously compromise the accuracy of results in some situations. In order to be able to use a program correctly it is desirable to have a level of understanding of the problem at or beyond the level of the analysis tool. Using software that demands input, the significance of which one cannot relate to, will inevitably lead to poor analysis results.

RECOMMENDATIONS

In choosing software it is important that a designer:

i) be realistic in setting standards of required accuracy

ii) be realistic about the amount of time and money he is prepared to invest or feel can be recovered directly from clients for carrying out analyses

iii) should choose software that has been designed to analyze the range of design issues he wishes to consider

iv) should not choose software that is beyond his level of understanding of the problem unless he is prepared to invest time into increasing his understanding.

Given this advice, the information provided in the text should help a designer choose an analysis tool that best satisfies his particular circumstances. The text gives some background information on basic calculation techniques and discusses current modelling weaknesses which should help a designer weigh his requirements in the light of current inherent modelling difficulties.

1 INTRODUCTION

1.1 THE EVALUATION PROJECT

For both new and seasoned users of energy analysis methods, the choice of an appropriate design or analysis tool is not an easy one. The potential user is faced with an inordinate number of methods to choose from and is subjected, more often than not, to conflicting claims of accuracy, scope, ease of use and cost.

With a view to providing guidance on the selection of appropriate tools, in particular computer methods for the design of passive solar residential buildings, the Solar Energy Program of the National Research Council of Canada initiated a project to develop a methodology for evaluating design tools and to use the methodology developed to evaluate a number of currently available and supported methods.

The specific aims of the project were:

- To develop a standard evaluation methodology that could be consistently applied to current tools and to new tools as they become available.
- To develop a list of features that are considered either essential or highly desirable in passive solar design tools.
- To identify those tools that meet or exceed these criteria.
- To select a number of tools for evaluation and carry out the evaluation.
- To make suggestions as to the ways that the proposed methodology could be improved.
- To provide a guide to potential users to help them qualify their own needs and to make an appropriate choice of design tool.

The evaluation project was carried out under the review of a Steering Committee comprised of both program developers and program users, from public and private organizations.

Throughout the project the authors of the programs tested were given the opportunity to review and comment on the evaluations and to check for any possible misrepresentations of their software.

This document which is only a partial summary of the work performed is primarily concerned with the last of the above specific project aims. More complete descriptions of the other aspects, where not covered in sufficient detail for the reader of this text, can be found in Reference 1.

Recognising that program accuracy is not the sole criterion for program selection, the methodology includes evaluations in the areas of:

- Technical Scope, i.e. the range of features or options that the software can analyse.
- Technical Accuracy, i.e. the accuracy with which the model can reproduce actual monitored test data and/or is sensitive to physical changes that we know in practice to influence energy usage.
- The ease with which the software can be applied in a typical practical situation.
- Cost, i.e. purchase, license or user fee, computer cost, related equipment costs and typical engineering costs.

The document does not aim to provide an overall rating of the programs evaluated; rather, it presents the strengths, weaknesses and scope of each tool which, together with the background discussion on simulation methods should permit potential users to select design tools which best meet their own particular needs. The current and near future state of the art means that a tradeoff between the above categories is inevitable. There is currently no single program that can accommodate **all** features with a **consistent and high degree of accuracy**, that is both inexpensive and easy to use. The tradeoffs can only be made by individual users cognizant of their own particular circumstances.

1.2 REVIEW OF BASIC CALCULATION METHODS

Some knowledge of the differences and inherent limitations of the basic calculation methods is considered valuable to the would-be analyst to help him see beyond unsubstantiated claims of technical supremacy of one method over another. The level of detail, sensitivity and accuracy of the range of methods available varies greatly. While the most complicated models are always computer methods, even the most simple calculation methods have been computerised and it should not automatically be assumed that a computer method is necessarily more accurate than a hand calculation method.

The simplest and probably oldest method for predicting energy usage is the degree day method and although it can be relied upon to provide reasonable predictions of energy in certain applications it is not, in its simplest form, useful to the passive solar designer primarily because the method is not sensitive to passive solar design features.

Many attempts have and still are being made to remove the basic degree day methods limitations, i.e. its sensitivity to the single parameter overall heat loss. Because of its inherent simplicity the degree day method or its deriva tives are still popular with many designers. Early attempts to expand the method included correction factors to account for intermittant heating, building mass and alternate ratios of space gains to envelope loss — this last item being handled by using degree days calculated to different base temperatures.

In recent years attempts have been made to develop manual methods specifically for passive solar analysis and the degree day method or its derivatives have found their way into some of these "advanced hand methods"; e.g. the Okins, Leipciger, Cuplinskas, Kaminker method described later.

In a move to develop simple hand calculation techniques, a number of methods have been devised. Perhaps the most well-known of these methods is the Solar Load Ratio (SLR) method. This, along with the two other methods described below, can be thought of as "correlation methods", i.e. the methodologies are based on the results of a large number of detailed hour-by-hour simulations, representing a range of various design strategies "correlated" or "represented" by some simple relationship or set of relationships. All these three methods rely upon degree day type of calculations for the calculation of the non solar component of the building heat balance with the correlations or empirical relationships being used to determine the amount of solar gain actually contributing to the heating of the building.

In the case of the SLR method the solar contribution is correlated with the ratio of monthly solar gain and monthly building load (the "Solar Load Ratio"). These correlations have been established for a large number of reference passive solar designs which include nine direct gain systems, fifteen water and forty-two Trombe walls, and twenty-eight sunspace systems. This is not to say the designer has only an option of choosing one of 94 standard buildings, the actual solar contribution to these reference designs is influenced by climate, characterized by the ratio of solar radiation to degree days and by the actual amount of glazing relative to the building heat loss (the "Load Collector Ratio" or "LCR"). Reference 2, which gives a detailed account of the method, provides look-up tables giving solar contributions as a function of design type ("reference design") climate and load collector ratios. Monthly heating requirements are calculated using degree day tech niques from which the solar contribution is subtracted to arrive at a figure for auxiliary heating consumption.

In Canada two other methods specifically oriented to passive solar buildings are of particular interest.

The first of these is a manual tech nique developed by Okins, Leipciger, Cuplinskas, Kaminker & Associates for the Ontario Ministry of Energy.

The method addresses direct gain systems with or without night shutters, a mass wall system and a sunspace strategy. As with the above method such contributions are correlated with the ratio of solar gain to heat load and monthly heating consumptions are calculated in a manner similar to the SLR method using a modified degree day formula. The solar correlations are given for the direct gain case in which it is assumed that there is sufficient mass to limit the inside temperature swing to no more than 7°C while the mass wall correlations are for a specific wall design. Supplementary calculation methods are described in Ref. 3, which gives full details of the method, allowing the user to study the relationship between mass and temperature swing.

The second method was developed at the National Research Council by Sander and Barakat and is referred to as the "Solar Utilisation Method". In this method which need only be carried out on an annual basis, the useful solar contribution is correlated to two parameters, the ratio of the solar gain to heating load and the ratio of solar gain to building interior mass. The "non solar" portion of the calculation is carried out using the average heating season inside to outside temperature difference, and the number of heating season hours with an allowance made for any heating contributions from internal heat gains. Unfortunately the method can currently only accommodate a simple direct gain strategy, although the handling of mass variations and temperature swings is more complete and more elegantly handled and easier to use than the two previous methods.

The method is fully described in References 4 and 5 and has been found to compare well with the measured energy consumption data obtained at the NRC passive solar test huts. Calculations may also be carried out on a monthly basis if so required and this procedure is in fact the basis of thermal calculations used in the Canadian programs HOTCAN and CMHC2.

A significant drawback to the above advanced manual techniques is their limitation to a restricted number of design combinations; this is a practical restriction rather than a theoretical one since to cover all possible design combinations with a high degree of sensitivity would demand inordinate volumes of look-up tables. To improve the sensitivity and scope of the analysis method, it is necessary to move away from pre-solved solutions to more generalised "detailed simulation models". Such methods rely on the analyst to "build" a model of the proposed design. This model may be a mathematical model or an analogue model.

Analogue methods make use of the analogy between flow of electricity and the flow of heat. Because of the time and complexity involved in developing the hardware network representing the building (which may take several weeks) these methods are usually restricted to research environments.

Mathematical models are often classified according to the analytical method used, and here there are two basic approaches.

The inherently more rigorous and generalised approach is the finite difference method or "detailed numerical solution" or "heat balance method" as it is variously referred to. In simple terms it can be thought of as the mathematical equivalent of the analogue method: the building being represented by a network of nodes connected to each other, as in the case of the building fabric, by thermal resistances partitioned by lumps of thermal capacitance.

The main drawback with such methods, although this is becoming less significant with increasing computer power, is the computation time (and cost) necessary for the mathematical solution. This computation time increases rapidly with increasing complexity of the model since there are more equations to solve. Finite difference models are, however, generally considered the preferred route for passive solar design analysis. Although, in an attempt to fit such models on small computers and/or limit computation costs, many finite difference models are somewhat restricted in their applicability. For example, they may be limited to the analysis of a single thermal zone or they may exclude heating and cooling systems and equipment simulation.

Such limitations may outweigh any potential benefit they may have had over the alternative Response or Weighting Factor method (References 6 and 7). This method avoids having to solve heat balance equations by using a pre-derived response of a building component, e.g. a wall, or a complete room, to thermal disturbances such as heat losses and solar gains. These pre-derived responses, "response factors", may be found experimentally, which would of course limit the methods applicability to configurations similar to the experimental set-up, or they can be calculated. This calculation can be done external to the analysis tool for a range of typical building components and spaces, these "pre-calculated response factors", can then be built into the analysis tool. In order to extend the range of applicability to non-typical or non-traditional building design, these responses can be calculated for each unique building configuration prior to carrying out the hourly analysis. Such a technique has been tagged as the "custom weighting factor method" and is, for instance, an option in the U.S. public domain program DOE 2.1B.

A practical limitation of such methods, however, is that changes to the properties of the layers or spaces cannot be made without recalculating the response or weighting factors, i.e. the method is limited to linear relationships and therefore cannot, for instance, treat longwave radiation exchanges or changing sunlight patterns in a room in a rigorous manner without having to recalculate these factors.

Again it is very important not to assume that finite difference methods are more accurately or more widely applicable than response factor methods since both are only mathematical techniques. One must look further into how explicit the actual model is - for instance, one could set up a very simple finite difference model that, to take an extreme example, ignored building mass and which would be quite inadequate for predicting passive solar building performance.

1.3 CURRENT THEORETICAL AND PRACTICAL MODELLING LIMITATIONS

Regardless of the mathematical basis of the model all current software can be expected to have some modelling weakness. Modelling weaknesses occur for many reasons such as;

i) a more rigorous solution would require a larger computer or unacceptable computation time or costs.

ii) the rigorous solution would make software difficult to use, i.e. not commensurate with the accepted level of design or analysis effort.

iii) a simple solution can be accepted as adequate over a specific and restricted range of planned use of the software. This is often dangerous as program authors rarely highlight these restrictions while designers by nature are prone to use software in ways that the program authors never imagined.

iv) the lack of commonly accepted, tested or adequate theoretical bases for modelling certain physical phenonemon.

v) the lack of control over the construction and use of the building rendering assumptions made during the design stage potentially very different from those that might be experienced in reality.

vi) the lack of adequate weather data.

vii)poor design of the software.

When looking at software one should not be too critical of those programs that do not reflect all the sophistications that our current collective modelling expertise would allow. Indeed such a program should it exist would currently be likely to be too complex and time consuming for all but a few dedicated experts to use. One would expect, however, that the gap between program accuracy and ease of use should narrow with improved algorithms, computer hardware and programming techniques.

The potential user of software should be on the lookout for:

i) poor software design, for example, the use of outdated algorithms and methods where more accurate and/or simpler methods are available.

ii) conscious omissions, i.e. where the program designer has had quite specific ideas on the use of the software. Do not choose software intending to use it outside of the scope for which it was constructed.

iii) claims of accuracy in those areas where accuracy is limited by current knowledge or practical constraints - a brief description of which are given in Table 1.3.1.

Modelling of Absorbed Solar Radiation & Longwave Radiation Interchanges in an Interior Space

Most methods avoid rigorous geometric modelling of the continuous variation of the sunlit surface and detailed modelling of radiant and convective heat exchanges within the space. The current lack of monitored solar data in direct and diffuse components contributes to the modelling weakness.

Modelling of Air Infiltration

Most models currently lag the state of the art as far as infiltration modelling is concerned. Certain practical considerations such as the problems of obtaining specific local wind data, the constant fluctuation of wind speed and direction in time steps considerably shorter than I hour and the problem of being able to accurately predict construction air leakage performance will understandably limit modelling accuracy in this area.

Modelling of Zone to Zone Coupling

The prediction of naturally induced air movement, by thermal differences and infiltration paths, is a theoretically neglected part of modelling and one which should be capable of being improved substantially over its total current lack of consideration. Also solar energy passing through one zone into another is not normally addressed in a rigorous manner.

Heat Loss to Grade

Modelling is less than ideal in most current software and generally lags scientific knowledge. The uncertainty of soil conditions, particularly the presence of water in and around the pro posed building site will, however, ultimately affect the absolute accuracy of any energy prediction.

Multi-dimensional Heat Flow

This is becoming increasingly important as superinsulation levels are adopted. The problem is often ignored or the user must rely on external hand calculations.

User Effects

User effects includes the following:

i) the actual occupancy of the proposed dwelling with the associated heat gain (including use of appliances and domestic hot water,

ii) the adjustment of thermostats and how this might be related to radiant effects and draughts,

iii) the use of exhaust fans and the opening of windows.

Greater interest in the "occupant effect" and how he responds in a building should both improve design and make for more accurate energy predictions.

TABLE 1.1

2 THE EVALUATION PROCEDURE

2.1 DEVELOPMENT OF AN EVALUATION METHODOLOGY

The intent of the evaluation project was to develop a standard and reproducible procedure for evaluating passive solar design analysis tools. Further the evaluation was to address a wider range of issues than just program accuracy which had been the major preoccupation of many earlier activities. It would not, however, be an attempt to carry out a complete and comprehensive testing of software nor was the intent to correct software.

Program evaluation was ultimately carried out in four areas: technical scope, technical accuracy, ease of use and cost. These categories are explained below. As previously indicated, at the current and foreseeable future, it will be necessary for design tool users to make tradeoffs in and between features in these categories in order to select a design tool that overall best meets their needs.

2.2 TECHNICAL SCOPE

The technical scope of a design tool is the range of options, building and systems features that the program can model. The "evaluation" under this category must be made by the actual purchaser of the software who needs to confirm whether or not the features he is interested in can be accommodated. To facilitate this identification the "evaluation methodology" requires that a program's capabilities be tabulated in a common format which will serve as a checklist to the user; as to which facilities he should consider; as a means of quickly comparing the scope of alternative software.

2.3 TECHNICAL ACCURACY

Technical accuracy is addressed at two levels: the first being what we have termed "sensitivity" and the second as "actual accuracy".

Sensitivity can be considered a first step towards calculation accuracy, i.e. on the assumption that more sensitive programs are potentially more accurate, though not necessarily so. By sensitivity we mean the ability of the software to take account of those physical features that are known to have an effect on energy consumption. The actual sensitivity evaluation is conducted using a list of key sensitivity issues as considered relevant to passive solar analysis of residences.

Sensitivity can in may instances be determined from the input required by the program. For instance, to take a simple example, if building or component mass is a required input, it is likely that the software is sensitive to building mass, i.e. that the model is not a steady state model. Not all sensitivity issues can be dealt with so easily and for thoroughness it is necessary to explore the individual procedures (algorithms) or program reference material. In some cases a program may be sensitive to a detail but may rely on the program user to make some arbitrary or rough estimate of its effect rather than have it treated in a rigorous mathematical manner in the program code.

An example of this is sensitivity to mass placement. A heavy mass wall directly and continuously exposed to direct sunlight would have a different effect on passive solar contribution than would the same wall if it were completely shaded from direct radiation. None of the programs evaluated treated this aspect in a rigorous manner using geometric relations and sun positions to calculate the continuously changing pattern of directly radiated interior room surfaces. Some design tools, however, displayed some sensitivity to mass placement but relied on very approximate methods, e.g. allowing the user to assign the fraction of solar radiation to various building surfaces — the fraction being constant through hourly and annual variations.

The testing of actual accuracy is considered to be less than ideal principally because of the current lack of suitable monitored data. Ideally confidence in the accuracy of a program can only be assured by comparing simulated with actual monitored and validated data. The practice of using so-called "validated" programs to check the accuracy of other programs leaves some element of uncertainty. Unfortunately, there is a limited amount of reliable monitored data from closely controlled experiments and what is available is only for a partial heating season.

This presented a problem of finding sufficiently varied data to model a range of features (technical scope) and of providing sufficient data for the testing of those programs not capable of providing hourly or daily data.

	Principle Characteristics	Secondary Charateristics
NRC OTTAWA	*Direct Gain*	
	Lightweight Construction	*Glass to Floor Ratio = 0.09*
	Direct Gain	
	Heavyweight Construction	*Glass to Floor Ratio = 0.09*
	Trombe Wall	
	South Facing Vented Trombe Wall	*See Note (ii)*
	Sunspace	
	Attached Sunspace	*See Note (iii)*
U OF ALBERTA	*Energy Conservation*	
	Superinsulation Levels	*Glass to Floor Ratio = 0.12*
	Passive Solar	
	Direct Gain	*Glass to Floor Ratio = 0.24*

TABLE 2.3.1 TEST CELL CHARACTERISTICS

NOTES:

i) The Alberta test cells have full basements, while the NRC test cells were thermally isolated from the ground.

ii) It is suspected that there was little thermosiphon action in the Trombe wall during the 14 days of measured data.

iii) The fan between the sunspace and south room of the sunspace test cell was controlled to come on when the sunspace was 2.5 deg. C. warmer than the south room. There was no exhaust fan in the sunspace but the exhaust fan in the south room was activated when the temperature exceeded 25 deg. C. (see Reference 8). None of the programs tested could model this arrangement.

At the time of preparing the evaluation material, data from complete houses was not considered suitable for evaluation purposes. In their place test cell data from experimental facilities at the National Research Council in Ottawa and the University of Alberta were used. Descriptions of these test cells can be found in References 8 - 12. The test cells cover a range of design features as detailed in Table 2.3.1. From information available from these facilities a continuous period of error free data was selected for each test cell. A 14 day period was selected for the NRC test cells (December 29th to January 11th, 1981, except for the sunspace test cell which was in February, 1982). A 10 day period in January, 1982 was chosen for the Alberta facilities. This hourly data was used as the basis for comparison of those programs whose calculations are made hourly and where hourly data is available as output. For checking the accuracy of the monthly evaluation programs monthly data for a complete year was generated based on the hourly programs that matched the monitored data in a satisfactory manner. (For additional confidence the NRC experimental house simulation program ENCORE was also used.) Because of the uncertainty associated with the extrapolation of the 10-14 day model to a full year model, an arbitrary confidence limit of $\pm 10\%$ was placed upon the generated data and monthly models are compared against this range. The method is described in detail in Reference 1.

In addition, to design strategies not covered by the test huts or as an aid to identifying specific algorithm weakness, parametric analyses were pursued which entailed:

i) eliminating all glass from the NRC lightweight test cell

ii) adopting a set-back strategy from the NRC lightweight test cell

iii) removing the basement from the Alberta passive solar test hut

iv) assuming no infiltration from the Alberta passive solar test hut

2.4 EVALUATION OF EASE OF USE

While there are undoubtedly many aspects of ease of use or "user friendliness" that are purely subjective and possibly elusive to articulate, user friendliness does not happen by chance; it must be built into the overall software package as carefully as any algorithm is fitted into the simulation code.

If user friendliness can be built into a program then to some extent the ease of use of a program can be assessed by dissecting the program and looking for those aspects that are known to make software easy to use. This is the basic philosophy of this section of the evaluation . The checks that have been used have been compiled from a review of literature on the subject and they are no more than a compilation of things that are recognised to contribute to ease of use; they are not necessarily a formula for developing the most user friendly software. Information on the subject is scarce and there are undoubtedly many other features currently existing and others yet to be derived that could be used.

In order to capture some of the subjective nature, parts of the ease of use evaluation were duplicated by two other organisations. For practical purposes and since it is necessary to recognise where certain aspects of ease of use are irreconcilable with other desirable software features such as technical scope and accuracy, the evaluation is carried out under a number of categories as described below.

• User-Machine Dialogue• This aspect covers the ease with which the user interfaces with the machine, i.e. it addresses the actual process of inputting data into and receiving data from the computer. Evaluation is made in two ways. The first involves a comparison of the software's input-output procedures against a set of rules or guidelines for satisfactory user interfaces. The second involves the recording and comparison of the time taken to input new data and edit existing data files when the various software is used to carry out similar new simulations and parametric runs.

• Input Data Requirements• This part of the evaluation is concerned with the time taken, and indirectly the ease with which the input data required to run the model can be collected. Two tests were applied, the first involves a counting of the number of parametric types*, the number of these that can be defaulted and the number for which reference material is provided directly in the software or in the documentation. This tells us something about the potential ease of use since programs requiring a large number of parameter types are potentially more difficult to use than software with only a few. Such difficulties can, however, be minimised by providing default values or by providing reference material to aid in the selection of values of parameters, such as material conductivities or glass characteristics to be selected without recourse to other reference works.

The second test involves the comparison of the times taken to collect the various information necessary for each analysis tool to model a number of test cases representative of a range of simple to complex structures. The simple structures were the test cells used in the accuracy analysis, the complex was a complete house - see Appendix D for details.

• Output Data • This part of the evaluation is concerned with determining how well the output data satisfies the requirements for identifying potential input errors or potential modelling problems. It is also determined how well the output data provides sufficiently detailed information in a format useful during the design process and/or for presenting to clients, i.e. without further manual calculations, re-typing or plotting or recourse to program documentation to look up the meaning of cryptic code words.

• Program Code • Program code is evaluated by comparing the code structure against standards for good programming techniques with a view to establishing the ease with which the code might be modified or calculation techniques identified and followed as an aid to correct use of the program.

• Documentation • Documentation is evaluated by looking for completeness, order and clarity in the material provided with the software.

• Consistency of Calculated Results • On the hypothesis that consistency of calculated results reflected ease of use, (i.e. from different users using the same software on the same problem,) the methodology provides for the duplication of selected analyses and a review of the various results. This activity produced some expected and some unexpected results which are discussed in the section on program comparison.

* Examples of parameter types are 'U-value', 'Orientation' 'Glass Area' for which numerical data is required to be input.

2.5 EVALUATION OF COSTS

Like technical scope, the actual evaluation of costs associated with the software can only be made by the potential purchaser who must decide whether or not he can afford to purchase and use the software. To facilitate this discussion the methodology requires that all possible costs associated with the purchase and use of the software be tabulated. This is done under the headings of "initial purchase cost", "hardware costs", "weather data costs", "learning costs", "engineering costs" (i.e. an engineer's time to use the program), and "running costs".

2.6 SELECTION OF PROGRAMS FOR EVALUATION

In order to make a selection from the numerous design tools available (there were over 400 identified as potentially useful)*, a minimum specification, consisting of features considered either essential or desirable specifically for Canadian users, was formulated and these features are described in the following. The software should:

i) Provide answers to what are considered the three most basic thermally related questions surrounding a particular passive solar strategy, i.e.

- Does the strategy reduce the annual energy consumption?
- Does the strategy compromise comfort in the occupied space?
- Does the strategy increase or decrease required equipment capacities?

To answer these questions, the following is considered necessary:

(a) the calculation of annual energy consumption (i.e., auxiliary heat consumption)

(b) an overheating analysis

(c) the calculation of peak heating load. Calculation of cooling load is not considered essential for residential construction in Canada.

ii) Be capable of modelling more than one passive strategy, otherwise there is limited basis for comparison of passive features. As a minimum, the software should handle simple direct gain, sunspace, and to a lesser degree, indirect gain strategies. Ideally the software should offer the ability to simulate other "conservation" strategies for the purposes of being able to compare and combine passive with other non-passive strategies.

(iii) Be capable of simulating typical Canadian residential construction features including amongst others, the ability to simulate basement heat loss and attached shading.

(iv) Be U.S. or Canadian in origin and available for use by a designer and be supported.

(v) Be commercially available for use by designers.

(vi) Not be research-oriented (which ruled out such programs as DEROB).

(vii) Be oriented primarily to single family residential construction (which ruled out such programs as DOE and BLAST).

Further, in order to satisfy the required technical scope as implied by (i) and (ii) above, it is considered necessary that the software be sensitive to building mass and to internal partitioning demanding that the model be multi-zone and able to simulate heat transfer between spaces at differing temperatures. This is particularly important for the evaluation of sunspaces.

Of the programs for which information had been collected only five programs appeared to satisfy these requirements, namely, ENERPASS, CALPAS3, SUNCODE, MICROPAS and SERI-RES. Of these, SUNCODE and MICROPAS were dropped from further testing on the basis of their respective similarities to SERI-RES and CALPAS3.

In order to encompass simpler design tools which did not meet all the minimum criteria, other programs were added to the list for evaluation; namely, F-LOAD, a popular U.S. program; Canadian government sponsored programs HOTCAN and CMHC2; CASAMO, a French language program; and lastly, SUNPAS, a SLR based program by SOLARSOFT.

* A database containing information on these 400+ analysis tools can be found in Reference 1.

3 PROGRAM DESCRIPTIONS

In this chapter each program is discussed individually; comparisons between the various programs tested are made in the following chapter.

General information such as program author, calculation methodology major algorithms used and hardware requirements are presented along with the most significant aspects resulting from the evaluation of accuracy and ease of use. Full details of program scope and costs are given in table form in the following chapter, where the information can be easily compared with the other programs tested.

A typical analysis session is also presented in the form of a flowchart to give the potential user a better idea of the actual process of using the program. Where appropriate the accumulative time required to complete each function is noted. For simplicity and clarity not all possible user operations are included in these example sessions.

3.1 CALPAS3

PROGRAM:

CALPAS3 (Version 3.11)
Program Authors:

Berkeley Solar Group 3140 Martin Luther King Jr. Way Berkeley, California 94703 (415) 843-7600

PURPOSE:

The program was developed to model the thermal performance of residential and small commercial buildings. Specifically, CALPAS3 is oriented towards passive solar design.

METHOD:

CALPAS3 is a thermal network program that can model an unlimited number of walls and windows oriented in any direction. Up to five mass elements can be modelled each using five temperature nodes. Networks, up to 38 nodes in total, can be automatically set up using a building description language. Up to 3 air nodes are permitted, i.e. up to 3 zones can be simulated but the second and third zones are essentially restricted to the simulation of a sunspace and a rockbin. The nodal equations are solved hour by hour, using a finite difference equations solution developed by Crank and Nicolson.

HARDWARE & RELATED SOFTWARE:

This evaluation was based on the version of CALPAS3 which runs on an IBM-PC. The program is also available for Data General and VAX computers and on a time-sharing system (offered by the Berkeley Solar Group).

In addition to a printer, the program requires that the IBM-PC have a minimum of 256K RAM and two disk drives. An "8087" coprocessor is recommended, for reducing the computation time.

The program requires that file or text editing software be used to create and edit the input files. EDLIN (provided through the IBM-PC disk operating system) is more than adequate to meet this requirement.

PROGRAM OPERATION:

Figure 3.1.1 outlines a typical session performed by a user to model a complex house design using CALPAS3.

CALPAS3 requires that the user create and edit input files using a text editor. The input file consists of a command language made up of keywords and values which are used to describe the building.

Commands on the CALPAS3 program disk are used to "call up" the desired input and weather files, select the run period, start the calculation procedure, etc. Each of the program commands has one charcter abbreviation.

MAJOR PROGRAM FEATURES:

CALPAS3 is oriented towards the simulation of passive solar designs which may include the following features: attached sunspaces, mass walls, waterwalls, rockbed storage, Trombe walls, movable window insulation, variable window shading, over hangs and side-fins, natural and forced over-temperature ventilation, and evaporative cooling.

At the time of testing CALPAS3 compatible Canadian weather data were not available but were being produced and are now available.

The program as tested was not capable of simulating basement heat loss (only slab heat loss to grade may be modelled); how ever, this will be available in a future version.

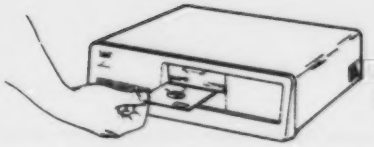
The program models infiltration and natural ventilation. The user is required to specify a base air change rate and air change "factors" to account for stack and wind driven infiltration. Natural ventilation is calculated using an ASHRAE algorithm that is sensitive to stack and wind driven flow.

The program allows the user to assign for each window up to twenty-eight fractions (representing 14 summer and 14 winter values), which are multiplied by the solar gain passing through the window. By this means the solar gain may be "linked" to up to six types of thermal mass located in the house, and up to four located in each of the sunspace and rockbed. There is little guidance available in the documentation to assist the user in calculating this constant value (the true value would vary continuously with time of day and year).

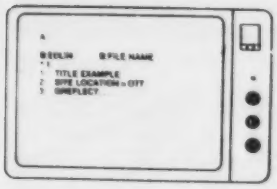
CALPAS3 is capable of outputting annual, monthly, daily or hourly values of the building energy balance (which includes heating and cooling energy consumption); room sunspace, and storage temperatures; and weather data. Annual and monthly heating and cooling peak loads, and annual fuel cost may also be output. (See Figure 3.1.2 for typical output.)

7 **DATA COLLECTION** EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATIONS" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS.

14 **INPUT DATA PREPARATION** FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT THE DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM.



INSERT PROGRAM AND WORKING DISKS IN DISK DRIVES (SEE NOTE 2)



INPUT DATA
— LOAD EDITOR & TYPE IN INPUT DATA SET.

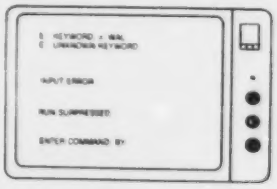
15

EDIT DATA
- LOAD EDITOR & EDIT EXISTING INPUT DATA SET

EXIT EDITOR & LOAD CALPAS 3

DEFINE SIMULATION & RUN PROGRAM
— GIVE FILENAME (INPUT FILE) WEATHER DATA & SIMULATION PERIOD (SEE NOTE 1)

15:03



PROGRAM CHECKS FOR ERRORS IN INPUT DATA

EXIT CALPAS3

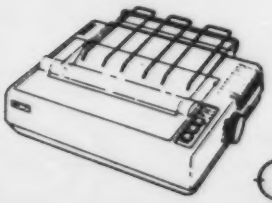
PROGRAM CONTINUES WITH COMPUTATION IF NO ERRORS 15:04

END OF SIMULATION 15:09

OUTPUT PRINTED

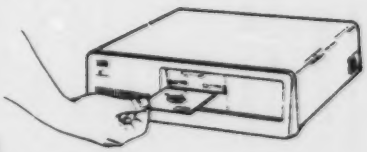
EXIT CALPAS3 → **ADDITIONAL RUNS REQUIRED?**

YES



15:20

NO



REMOVE DISKS

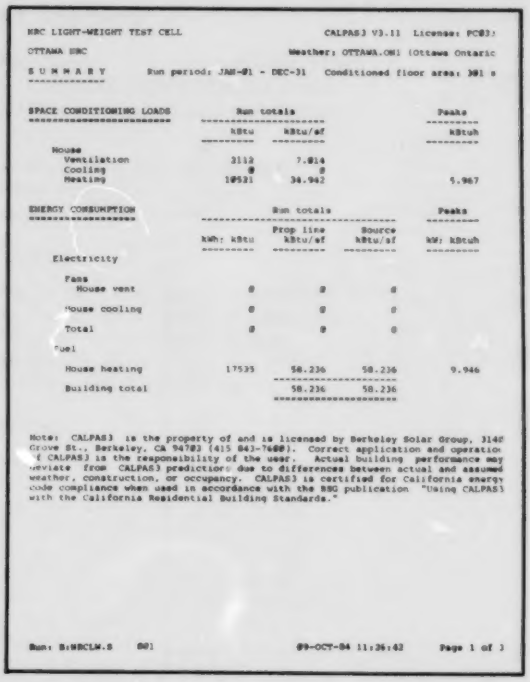
NOTES:

TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN. SEE APPENDIX D FOR DETAILS. THE FULL RANGE OF FEATURES AND DISPLAYED INFORMATION ARE OMITTED FOR CLARITY.

NOTE 1 EXISTING INFORMATION SUCH AS RUN PERIOD AS STORED ON EXISTING OLD FILE IS DISPLAYED AN BE REUSED TO AVOID TYPING BY PRESSING RETURN KEY.

NOTE 2 A COPY OF THE EDITOR WHICH IS TO BE USED. E.G. 'EDLIN' MUST BE PREVIOUSLY COPIED ONTO THE WORKING DISK. IT IS ASSUMED THAT AT THIS POINT THE COMPUTER HAS BEEN TURNED ON & THE DISK OPERATING SYSTEM (DOS) LOADED.

FIGURE 3.1.1 CALPAS3 - TYPICAL MODELLING SESSION



NRC LIGHT-WEIGHT TEST CELL CALPAS3 V3.11 License: PC#3:

OTTAWA NRC Weather: OTTAWA.OH1 (Ottawa Ontario

SUMMARY Run period: JAN-01 - DEC-31 Conditioned floor area: 301 s

SPACE CONDITIONING LOADS

	Run totals kBtu	Run totals kBtu/sf	Peaks kBtuh
House			
Ventilation	3112	7.014	
Cooling	0	0	
Heating	10521	34.942	5.967

ENERGY CONSUMPTION

	Run totals kWh; kBtu	Prop line kBtu/sf	Source kBtu/sf	Peaks kW; kBtuh
Electricity				
Fans				
House vent	0	0	0	
House cooling	0	0	0	
Total	0	0	0	
Fuel				
House heating	17535	58.236	58.236	9.946
Building total		58.236	58.236	

Note: CALPAS3 is the property of and is licensed by Berkeley Solar Group, 3140 Grove St., Berkeley, CA 94703 (415 843-7600). Correct application and operation (CALPAS3 is the responsibility of the user. Actual building performance may deviate from CALPAS3 predictions due to differences between actual and assumed weather, construction, or occupancy. CALPAS3 is certified for California energy code compliance when used in accordance with the BSG publication "Using CALPAS3 with the California Residential Building Standards."

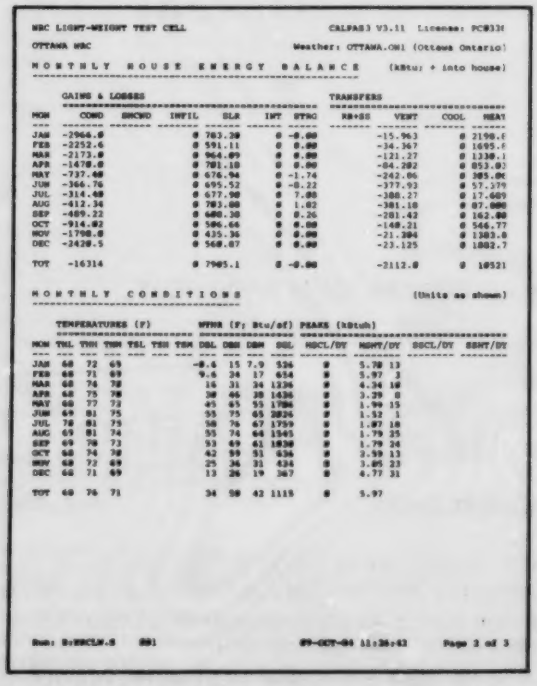
Run: B:NRCLW.S 001 09-OCT-04 11:26:42 Page 1 of 3

NRC LIGHT-WEIGHT TEST CELL CALPAS3 V3.11 License: PC#336

OTTAWA NRC Weather: OTTAWA.OH1 (Ottawa Ontario)

```
Line
-----  ------------------------------------------------------------------------
    1  TITLE NRC LIGHT-WEIGHT TEST CELL
    2  SITE LOCATION=OTTAWA NRC
    3  GREFLECT JANGR=.40 FEBGR=.40 MARGR=.40 APRGR=.25 MAYGR=.25 JUNGR=.25 &
    4           JULGR=.25 AUGGR=.25 SEPGR=.25 OCTGR=.25 NOVGR=.25 DECGR=.40
    5  NOUT 6.00
    6  HOUSE FLAREA=301.1 CAIR=085.7
    7  ROOF UVAL=.043
    8  WALL NAME=SOUTHWALL AREA=49.72 AZM=0 UVAL=.082 ABSRP=.2
    9  WALL NAME=NORTHWALL AREA=68.39 AZM=180 UVAL=.082 ABSRP=.2
   10  WALL NAME=WESTWALL AREA=244.0 AZM=90 UVAL=.082 ABSRP=.2
   11  GLASS NAME=SOUTHGLASS AREA=29.00 AZM=0
   12  GLASS NAME=NORTHGLASS AREA=18.33 AZM=180
   13  INFIL ACHASE=0
   14  INTGAIN INTGAIN=0 SCHED=RES AIR=1
   15  VENT TYPE=FAN CFMMAX=300 KWMAX=0
   16  TSTATSWNTR THEAT=68 TDSRD=77 TCOOL=150
   17  TSTATSSMR THEAT=68 TDSRD=77 TCOOL=150
   18  END

   *** No input errors.

   *** Beginning simulation    09-OCT-04    11:27:15

   *** Run complete.
```

Run: B:NRCLW.S 001 09-OCT-04 11:26:42 Page 2 of 3



NRC LIGHT-WEIGHT TEST CELL CALPAS3 V3.11 License: PC#33

OTTAWA NRC Weather: OTTAWA.OH1 (Ottawa Ontario)

MONTHLY HOUSE ENERGY BALANCE (kBtu; + into house)

MON	GAINS & LOSSES COND	SNCND	INFIL	SLR	INT	STRG	TRANSFERS RS+SS	VENT	COOL	HEAT
JAN	-2966.0		0 703.20	0	-0.00			-15.963	0	2198.6
FEB	-2252.6		0 591.11	0	0.00			-34.367	0	1695.6
MAR	-2173.0		0 964.89	0	0.00			-121.27	0	1330.1
APR	-1470.0		0 701.10	0	0.00			-84.202	0	853.03
MAY	-737.48		0 676.94	0	-1.74			-242.06	0	305.08
JUN	-366.76		0 695.52	0	-8.22			-377.93	0	57.379
JUL	-314.48		0 677.90	0	7.00			-388.27	0	17.669
AUG	-412.34		0 703.00	0	1.02			-381.10	0	87.000
SEP	-489.22		0 680.30	0	0.26			-281.42	0	162.88
OCT	-914.02		0 586.66	0	0.00			-148.21	0	546.77
NOV	-1798.8		0 435.36	0	0.00			-21.304	0	1383.8
DEC	-2428.5		0 568.07	0	0.00			-23.125	0	1882.7
TOT	-16314		0 7905.1	0	-0.00			-2112.0	0	10521

MONTHLY CONDITIONS (Units as shown)

MON	TEMPERATURES (F) TBL	TAM	TSM	TBL	TAM	TSM	WTHR (F; Btu/sf) DBL	DBH	DBM	SOL	PEAKS (kBtuh) HRCL/DY	HRMT/DY	SSCL/DY	SSMT/DY
JAN	68	72	69				-8.4	15	7.9	536	0	5.78	13	
FEB	68	71	69				9.6	34	17	654	0	5.97	3	
MAR	68	74	70				16	31	24	1336	0	4.34	18	
APR	68	75	70				38	46	38	1436	0	3.29	8	
MAY	68	77	73				45	65	55	1786	0	1.99	15	
JUN	69	81	75				55	75	65	2034	0	1.52	1	
JUL	70	81	75				58	76	67	1759	0	1.97	10	
AUG	69	81	74				55	74	64	1545	0	1.79	25	
SEP	69	78	73				53	69	61	1030	0	1.79	24	
OCT	68	74	70				42	59	51	636	0	3.59	13	
NOV	68	72	69				25	36	31	424	0	3.85	23	
DEC	68	71	69				13	26	19	367	0	4.77	31	
TOT	69	76	71				34	58	42	1115	0	5.97		

Run: B:NRCLW.S 001 09-OCT-04 11:26:42 Page 3 of 3

FIGURE 3.1.2 CALPAS3 - SAMPLE OUTPUT

PROGRAM ACCURACY
CALPAS 3

■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
● -NRC TOMBE WALL TEST CELL
□ -NRC SUNSPACE TEST CELL
△ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

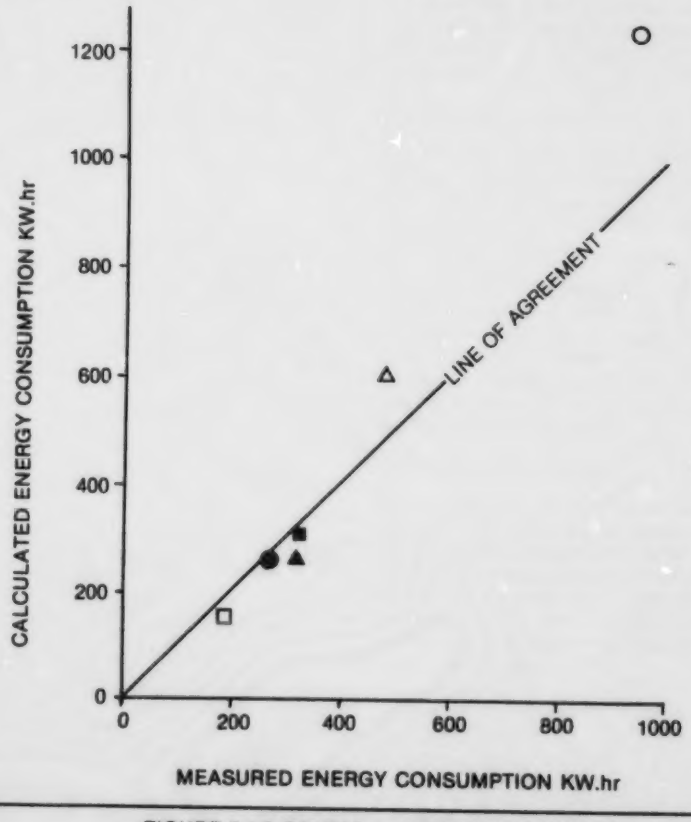


FIGURE 3.1.3 CALPAS 3 - PROGRAM ACCURACY

ACCURACY:

As shown by Figure 3.1.3 CALPAS3 produced "longterm" results that were consistent with the measured energy consumption for each of the National Research Council test cells that were modelled. However, hour-by-hour comparisons showed that the program tends to slightly overestimate the effect of solar gains (i.e., understimate the energy requirements during "sunny" days). This was particularly prevalent in the Lightweight Test Cell.

Poorer results were obtained against the Alberta Test Huts. This may be partially attributed to the lack of a basement model in the program (the two Alberta Test Huts had full basements whereas the NRC Test Cells had no heat loss to grade). It should be noted, however, that all the programs evaluated generally produced results for the Alberta Passive Solar test hut that were less consistent than for the NRC huts.

EASE OF USE:

The user is provided with detailed easy-to-read and follow documentation which allows the new user to learn and begin modelling in a short time. Engineering procedures and methods are identified and referenced in the documentation, but their applicability and limitation are generally not discussed. This and the fact that the program is capable of modelling fairly complex designs, requires that the user have some knowledge of heat transfer. A section on error checking procedures and a list of error messages would be helpful.

CALPAS3's input file can be long and awkward to set up as the "keywords", and "argument" names and values are numerous, and to the new user somewhat cryptic. Standard input sheets are available and are often essential. Argument names may be omitted, but then the sequence of the argument values becomes critical. A defence of such a method of creating input files is the fact that often the user need only edit an existing input file which usually can be done quickly and easily. Also, many of the values may be defaulted and where appropriate, dynamic defaults are used.

CALPAS3 becomes more difficult to use when the user has to resort "tricking" the program into simulating such features as full basements, ventilation and multiple interior mass walls of different construction.

CALPAS3 produces output headers which are cryptic; thus the new user must frequently reference the documentation.

CONCLUSIONS & GENERAL COMMENTS:

Overall, the strengths probably outweigh the weaknesses of the program. The well-organized and detailed documentation and the program's flexibility to model a wide range of building types (apparently fairly accurately) on a microcomputer are CALPAS3's greatest strengths. The program's weaknesses include a lack of a basement, ventilation and equipment models, and the cryptic input keywords and output headers.

3.2 CASAMO

PROGRAMME:

CASAMO (Version 82-A)

ARMINES-ENERGETIQUE
60 Bvd St Michel
75272 Paris CEDEX 06 FRANCE

329 2105 POSTE 480/550

BUT:

Le logiciel Casamo était développé pour aider à la conception d'un habitat. En particulier il sert à évaluer la qualité thermique pour ensurer un respect des réglementations francaises à ce propos.

MÉTHODE:

Casamo estime les besoins de chauffages annuels par un calcul mensuel avec les degrés-jours, les mêmes sont calculés d'après les températures moyennes mensuelles.

Il peut faire l'évaluation de la composante lumineuse de l'irradiation solaire incidente sur des plans d'orientations diverses (y compris l'irradiation horizontale totale) pour le site considéré. Il évalue les composants diffus à partir d'un ciel isotrope.

MATÉRIEL & LOGICIEL

Cette évaluation est fondée sur la version qui fonctionne sur un Apple II ou III. Le logiciel requiert 48 K RAM, deux lecteurs de disques, un moniteur et un imprimeur. Casamo est un programme auto-exécutable; donc, un logiciel de système d'exploitation sur disques n'est pas nécessaire.

EXPLOITATION DU PROGRAMME:

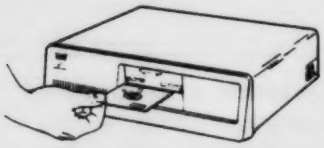
Casamo requiert que l'utilisateur choisisse dans le menu les parties différentes du programme.

Le système est piloté par menus dont l'utilisateur entre les données suite aux messages a l'écran. Casamo est constitué de quatre modules d'entrée dans une séquence. Premièrement l'utilisateur doit entrer des données climatiques après lesquelles on entre des données relatives à la description de l'édifice incluant les composants solaires et non-solaires. Il y a aussi le module pour enregistrer la description du système solaire actif.

La figure 3.2.1 dessous résume une session de modelisation type. Le logiciel écrit en Basic Applesoft n'est pas protégé, mais il ne comporte aucun commentaire dans les listages. L'exploitation du programme pour le Canada est compliquée par l'effet que certains noms de variables (et des abréviations) sont propres à la France.

CUEILLETTE DES DONNÉES TIRER LES INFORMATION DES ÉBAUCHES ET EXÉCUTER "DES CALCULES BANAL" TELS QUE LES SUPERFICIES DES MURS. 7:00

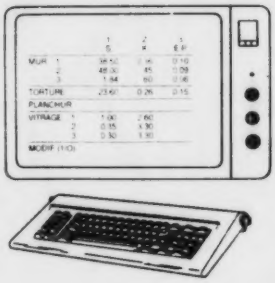
PRÉPARATION DES DONNÉES D'ENTRÉE REMPLIR LES FEUILLES DES DONNÉES. EXÉCUTER "DES CALCULES IMPORTANTES" TEL QUE LES DONNÉS EST DANS UNE FORME ACCEPTABLE AUX LOGICIEL. 8:00



INTRODUIRE CASAMO 1 DANS UNITE 1 ET CASAMO 2 DANS UNITE 2
- **ALLUMER LA MACHINE**

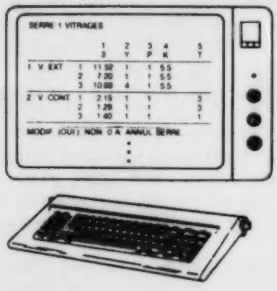
À PARTIR DU MENU, CHOISIR LE MODULE P-1
(ENTRÉE DES DONNÉES CLIMATIQUES. CALCULS DES IRRADIATION SOLAIRES)
- ENTRER L'ORIENTATION ET L'INCLINAISON DE LA SURFACE ET LES CARACTERESTIQUER D'OMBRAGE
- ÉVALUATION DE L'IRRADIATION SOLAIRE INCIDENTE SUR CHAQUE SURFACE

8:10



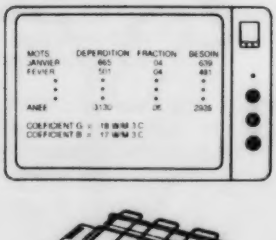
À PARTIR DU MENU, CHOISIR LE MODULE P-2
- ENTRER LES COMPOSANTS NON SOLAIRES P.EX., MURS, TOITS
- ÉVALUATION DE LA QUALITÉ THERMIQUE COEFFICIENT G

8:15



À PARTIR DU MENU, CHOISIR LE MODULE P-3
- ENTRER LES COMPOSANTS SOLAIRES, P.EX. FENÊTRES, ESPACES ENSOLEILLÉ, MUR TROMBE

8:20



À PARTIR DU MENU, CHOISIR LEMODULE P-4
- ÉVALUATION DE LA CONSOMMATION D'ÉNERGIE
- DONNÉES DE SORTIE

8:25

FONCTIONS REQUISES PARAMÉTRIQUE

OUI

NON

RETIRER DISQUES

RETIRER CASAMO 2 ET INTRODUIRE CASAMO 1 DANS UNITE 2, INTRODUIRE CASAMO 3 DANS UNITE 1
- ENREGISTRE LA FICHE DE TRAVAIL COURANTE SUR CASAMO 3

8:30

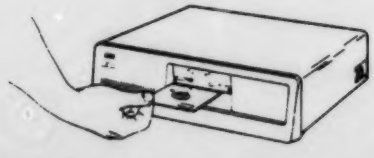
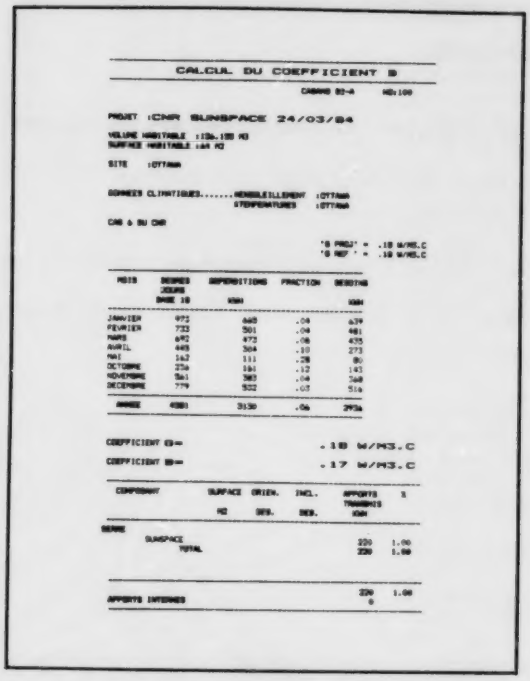


FIGURE 3.2.1 CASAMO - SESSION DE MODELISATION TYPE



CALCUL DU COEFFICIENT B

PROJET :CNR SUNSPACE 24/03/84

SITE :OTTAWA

MOIS	DEGRES JOURS DANS 18	DEPERDITIONS KWH	FRACTION	BESOINS KWH
JANVIER	972	640	.04	639
FEVRIER	733	501	.04	481
MARS	692	472	.06	435
AVRIL	445	304	.10	273
MAI	162	111	.28	80
OCTOBRE	256	184	.12	161
NOVEMBRE	561	383	.04	368
DECEMBRE	779	532	.03	516
ANNEE	4801	3130	.06	2954

COEFFICIENT B= .18 W/M3.C

COEFFICIENT B= .17 W/M3.C

COMPOSANT	SURFACE M2	ORIEN. DEG.	INCL. DEG.	APPORTS TRANSMIS KWH	X
SUNSPACE				220	1.00
TOTAL				220	1.00
APPORTS INTERNES				220 0	1.00

FIGURE 3.2.2 CASAMO - RÉSULTATS

CARACTÉRISTIQUES PRINCIPALES DU PROGRAMME:

Casamo permet l'entrée des caractéristiques d'unité d'habitation familiale, mais le sous-soul et le grenier sont considérés comme les espaces non-chauffés. Il peut évaluer jusque à huit surfaces ensoleillées quelles qu'en soient l'orientation ou l'inclinaison. Il fournit aussi la capacité d'ombrage naturel fondée sur un calcul horaire d'un jour type du mois.

Il y a l'utilisation d'un horaire prédéterminé pour l'existence éventuelle d'une isolation nocturne. (on répond 1 ou 2 selon le cas.)

Les besoins calculés par Casamo sont liés aux températures intérieures établies par le programme et la puissance de chauffe est instantanément ajustée aux besoins.

Pour le calcul des charges thermiques, la méthode Casamo ne tient pas compte de la masse thermique. Casamo utilise implicitement une correlation spécifique pour calculer la récupération des apports par les murs Trombe, mais aucune variation paramétrique est permise. Il n'y a aucune simulation du système mais le programme les calcule à partir de degrés-jours.
Il y a une séquence que fournit la performance du système solaire actif basé sur le principe de la charte F, mais il n'était pas évalué.

Le programme donne comme résultats la consommation de l'énergie thermique, la résistance de l'enveloppe, l'énergie solaire incidente transmise par les fenêtres, le coefficient d'ombrage et la perte d'énergie pour chaque composante. (voir figure 3.2.2).

PRÉCISION DU PROGRAMME:
Tel que démontré par la figure 3.2.3, Casamo a une très bonne concordance avec la consommation d'énergie annuelle évaluée pour la cabane d'essai de Alberta Energy Conservation et avec la cabane d'essai de CNR légère.

Toutefois la concordance est seulement adéquate avec la cabane d'essai du mur Trombe, probablement parce que l'utilisateur est très limité relativement à la description du mur Trombe. Il n'y a qu'une configuration type.

Les résultats sont moins bons avec la cabane d'essai lourde étant donné que Casamo ne considère pas la masse thermique. Il est de même pour la cabane d'essai avec une serre ou la capacité de stockage de la chaleur est limitée.

LE PRÉCISION DE LOGICIEL CASAMO

■ - Cabane d'irraditions solaires directe CNR construction legére, la proportion du vitrage au plancher .09
▲ - Cabane d'irradiations solaires directe CNR construction lourdes, la proportion du vitrage au plancher .09
● - La cabane du mur trombe CNR
□ - La logement d'une serre CNR
△ - La cabane de l'Alberta, la module en conservation vénérgie, la proportion du vitratrage au plancher .12
○ - La cabane de l'Alberta, la module du solaire passif, ia proportion de vitrage au plancher .24

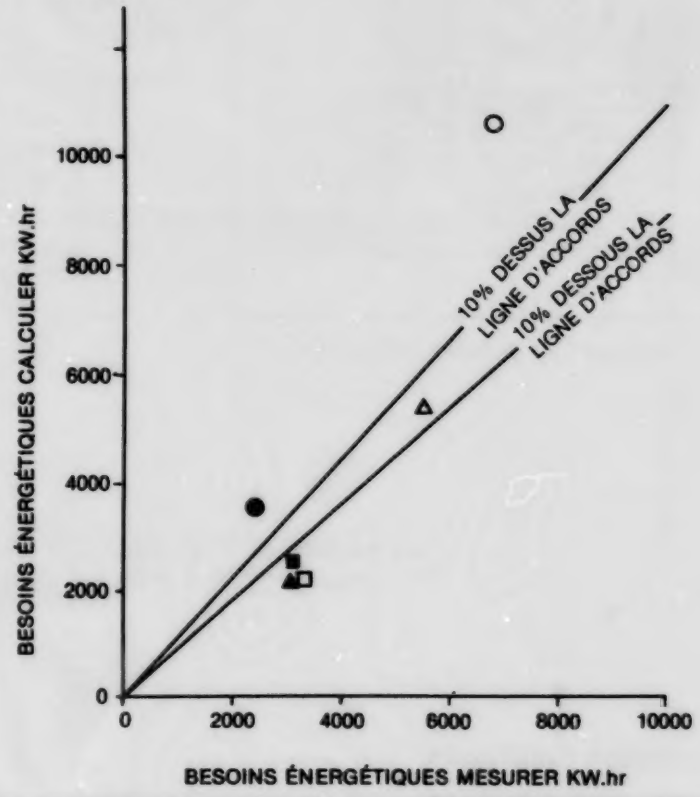


FIGURE 3.2.3 CASAMO - LA PRÉCISION DU LOGICIEL

FACILITÉ À UTILISER:

L'utilisateur se prémunit d'une bonne documentation, organigramme compris, bien organisé et lisible. Il y a des informations de référence pertinentes avec certaines propres à la France.

Les données du Casamo sont un programme à base de menus, donc la demande de mémoire est minimale. Il est difficile pour l'utilisateur parfois de retourner au menu approprié (surtout pour les nouveaux qui peuvent facilement s'y perdre) et il doit compléter chaque module d'entrées avant de passer à un autre module.

Il existe une méthode de vérification qui permet à l'utilisateur de visualiser les données qui ont été entrées (et de faire des modifications, si nécessaire) avant de passer à l'écran suivant.

Un utilisateur expérimenté trouvera le système d'entrées des données Casamo rapide et facile à utiliser. Les feuilles d'entrée de données sont fournies mais elles ne sont pas entièrement assorties au programme.

La sauvegarde et le recouvrement des programmes peuvent s'avérer difficiles car il y a une obligation de changer le disque d'unités de disques.

Casamo n'a aucune fonction de vérification d'erreurs et le programme acceptera toute réponse. Il est parfois difficile de cerner la cause de ce genre d'erreur bien que certaines réponses occasionnent une erreur de système (en Basic Applesoft, par exemple, division du zero).

Avec Casamo il est difficile de déjouer le programme et de l'amener à simuler certaines designs, par exemple les sous-sols chauffés.

CONCLUSION ET COMMENTAIRES GÉNÉRAUX:

Casamo est facile à utiliser, sans être trop simple. Il requiert un certain temps avant que l'utilisateur le trouve facile à manipuler. Les architectes affirment que c'est un bon programme puis qu'il suit les démarches de designs types, et que les informations de référence sont disponibles au besoins.

Les étapes de conception types sont apparemment conçues avec précision mais certains conceptes de caractère passif seraient difficiles a réaliser.

3.3 CMHC2

PROGRAM:

CMHC2
Program Authors:

Canada Mortgage and Housing Corporation,
Ottawa, Ontario K1A OP7
(613) 748-2308
CONTACT: Wayne Webster

PURPOSE:

CMHC2 (Computer Model for Heating Cost-effectively) is designed to model the thermal and economic performances of residential designs. At the time of the evaluation the program was still under development; it is planned to be made commercially available in the fall of 1985.

METHOD:

The program calculates a balance point temperature, below which heating is not required (this takes into account internal gains). An effective temperature difference, based on long-term average and extreme monthly temperatures is calculated for each month. These temperature differentials are used with the building thermal characteristics to determine heat loss. Solar gains are calculated using a correlation method described in Reference 4 and are subtracted from heat loss to determine the energy which must be supplied by the auxiliary heating equipment.

Other correlation methods have been developed to model infiltration, basement heat loss, heat loss to an unheated attached space and heat gain from domestic hot water.

HARDWARE & RELATED SOFTWARE:

CMHC2 runs on the IBM-PC microcomputer and when commercially available will require 256K RAM, an "8087 coprocessor" and two disk drives. A printer is highly recommended.

PROGRAM OPERATION:

The user may choose from six modes:

- Mode 0 - a "housekeeping" mode to create or modify input files for which an analysis is not immediately required.
- Mode 1 - the "energy analysis" mode; program calculates energy consumption based on the user-entered building description.
- Mode 2 - user enters "energy conservation upgrades". The program outputs a comparative analysis of upgrades along with the original Mode 1 output.
- Mode 3 - similar to Mode 2 except construction assembly costs and system costs (stored in data files) are used by the program to carry out an economic comparison of the alternative energy upgrades.
- Mode 4 - if this mode is selected the program will provide a list of potential upgrades (to both the envelope and mechanical system) based on cost effectiveness. Energy and cost analysis comparisons can be made between selected points in the list.
- Mode 5 - The program automatically adjusts the theoretical model to match the measured performance of an existing building. The approach is based upon the degree of confidence the user has in the accuracy of the description of each building component.

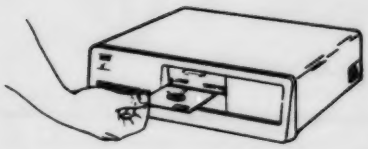
Once a selection has been made, the program displays the appropriate "screens" and the user uses a "full screen editing" process to enter data; i.e. cursor-arrow keys are used to position the cursor at the appropriate place on the screen, then the data are typed in.

A typical modelling session is shown in Figure 3.3.1.

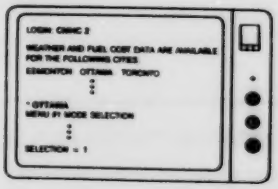
NOTE: This evaluation was based primarily on Mode 1.

7:00 **DATA COLLECTION** EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATION" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS.

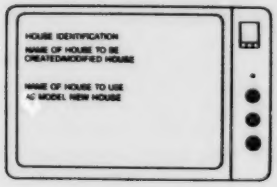
8:00 **INPUT DATA PREPARATION** FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT THE DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM.



INSERT PROGRAM DISKS, TURN ON MACHINE
- ACTIVATE PROGRAM - TYPE IN CMCH2.
- SELECT WEATHER AND COST DATA.
- SELECT MODE FOR MENU #1



8:02

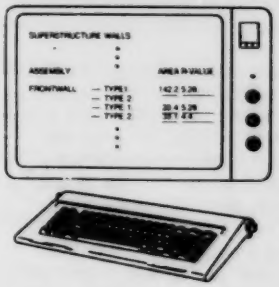


ENTER NAME OF HOUSE (FILE) TO BE CREATED OR MODIFIED
ENTER NAME OF HOUSE (FILE) TO BE SAVED.

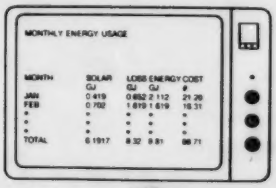
8:03

ENTER BUILDING DESCRIPTION

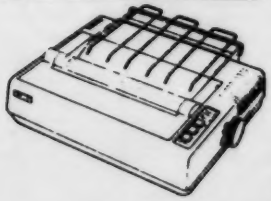
— SELECT THE APPROPRIATE SCREEN
E.G.1. HOUSE DESCRIPTION
2. OUTSIDE ENVIRONMENT
3. OCCUPANCY & LIFESTYLE ETC.
— USE THE CURSOR-ARROW KEYS TO POSITION THE CURSOR AT THE APPROPRIATE FIELD, THEN ENTER THE DATA.



8:23



RUN PROGRAM
— MAKE REPORT SELECTION
— PRINT OFF REPORT IF DESIRED

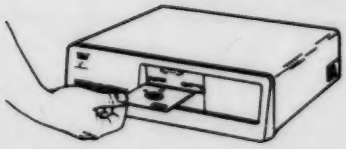


8:25

SELECT MODE FROM MENU #1

SELECTION = E — **END SESSION**

SELECTION = 1 → (returns to ENTER NAME OF HOUSE)



REMOVE DISKS

NOTES:

TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN. SEE APPENDIX D FOR DETAILS.
THE FULL RANGE OF FEATURES AND DISPLAYED INFORMATION ARE OMITTED FOR CLARITY.

FIGURE 3.3.1 CMHC2 - TYPICAL MODELLING SESSION

MAJOR PROGRAM FEATURES:

CMHC2 can model up to four heated zones each with different temperature setpoints, and two unheated zones. Zone to zone heat transfer is not calculated between heated zones. Conduction losses to unheated zones are accounted for (by specifying the percentage of total building heat that goes to the unheated space) but heat gains (such as solar gains) are not. Therefore CMHC2 cannot model attached sunspaces. The program can only model direct gain passive solar strategies. The user may select a light, medium, heavy or an infinite mass construction.

The user may define several wall types but is restricted to four orientations (front, back, left and right). Each wall is described by defining the area and construction. Construction can be defined by its properties, i.e. R-value, air tightness code, surface absorption; or by defining a wall assembly code. For one of a number of pre-defined constructions, R-values or assembly codes are specified for below grade walls and floors.

Each wall orientation may be assigned a "solar access code" (from 1 = no shading to 4 = completely shaded). A "completely shaded" receives 50% of the solar gain incident on an unshaded wall.

Infiltration may be entered as an air change rate (in Mode 1) or may be calculated using either CMHC2 or user-defined tightness codes (other modes). Allowances for the effect of building and chimney height, and furnace dampers have on air infiltration, are made by the program.

Oil, gas or electric heat options may be selected. The program assigns a default seasonal efficiency, based on the fuel selected, the default may be changed by the user. Furnaces with dampers, condensing furnaces and fireplaces may be selected; CMHC2 estimates their effect on infiltration.

Output reports are calculated in a very short time (CMHC2 had the shortest calculation time of all the programs tested, approximately 30 seconds) The user has a choice of reports, but all reports are not available in any specific mode. It is not always clear which report is available until the user tries to select a particular report. The reports are fairly readable and, with some explanation, would be suitable for inclusion in a report to a client. (A typical output report is shown in figure 3.3.2.)

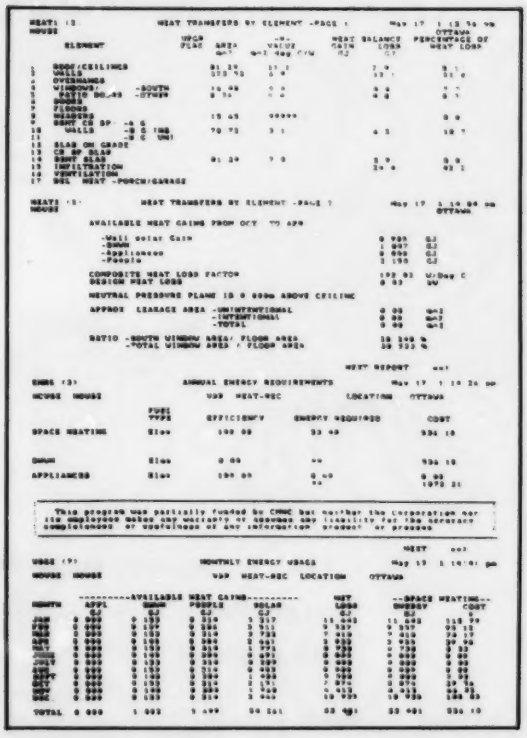


FIGURE 3.3.2 CMHC2 - SAMPLE OUTPUT

PROGRAM ACCURACY
CMHC 2

- ■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
- ▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
- ● -NRC TOMBE WALL TEST CELL
- □ -NRC SUNSPACE TEST CELL
- △ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
- ○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

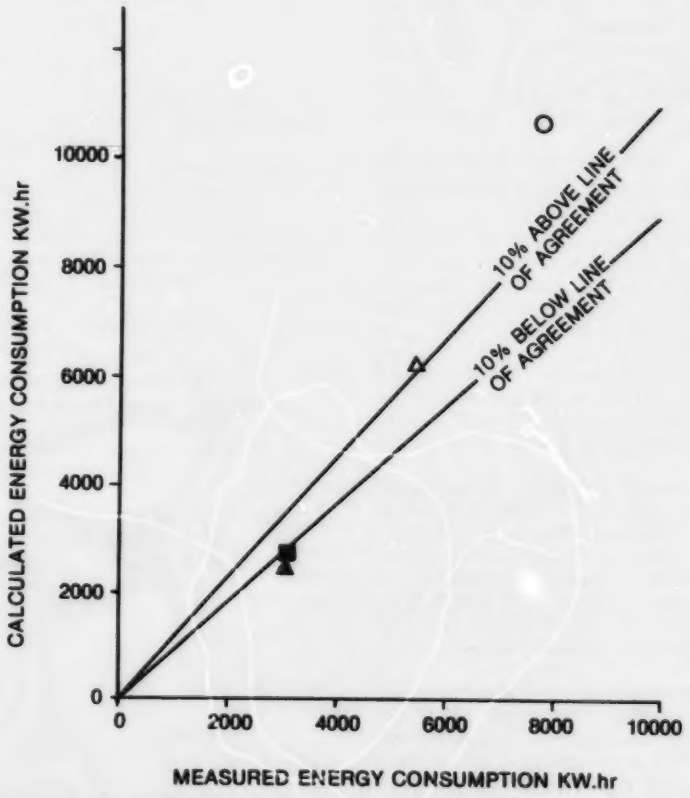


FIGURE 3.3.3 CMHC2 - PROGRAM ACCURACY

ACCURACY:

CMHC2 produced results fairly consistent with the estimated energy consumption for the NRC Lightweight and Alberta Energy Conservation test cells (see Figure 3.3.3). The results for the NRC Heavyweight test show that CMHC2 underestimated the annual energy requirements. A monthly analysis of the output reveals that during the spring and fall months the program underestimated the energy consumption of the Heavyweight test cell by as much as 40%. CMHC2 overestimated the annual energy requirements for the Passive Solar module by approximately 40%.

CMHC2 is not capable of modelling sunspaces or Trombe walls.

EASE OF USE:

At the time of the evaluation CMHC2 was an incomplete product, as it was still being developed. The evaluators did not have the benefit of a complete user's manual.

CMHC2 is menu driven which in theory should make it easy for a user to "find" his way through the program. Initially, however, the new user may get confused as there are six different modes. The menu driven sequence control, along with CMHC2 full screen data entry facility, potentially provides the user with a quick and easy way to enter and edit data, but there are a few problems:

i) the movement of the cursor with the cursor-arrow keys can be awkward.

ii) the use of cursor-arrow keys disables the number key pad. This forces the user to use the number keys on the top row of the keyboard; this is not as convenient as using the number pad.

iii) when entering a new building description, it is difficult to get back to the main menu as the program "locks" the user into a predefined "route" (through up to 14 screens) once the mode has been selected. However, modifying an input file allows the user to backtrack and skip forward through screens.

iv) default values are only displayed during the edit process (not during data entry). (The user is likely to always edit an existing file rather than create a new file because of items (iii) and (iv).)

v) headings are sometimes vague and it is not always clear from viewing the screen what to do next. A "help line" (line 25) showing the function of the most used keys and/or an on-line help facility would be an asset.

Despite the above-mentioned problems, CMHC2 has the most sophisticated data entry and error checking facilities of the programs tested. Unacceptable, questionable and inconsistent data are highlighted before the user is allowed to move to another screen. This system of data entry allows the user to quickly create error-free input files.

CONCLUSIONS & GENERAL COMMENTS:

Technically, CMHC2 provides the user with a fairly high level of sophistication to model the conventional or energy efficient house (especially for a model based on monthly calculations). The program is not particularly oriented towards passive solar heating, making it difficult or impossible to model certain features (e.g. attached sunspaces and Trombe walls).

CMHC2's greatest strengths are:

- the "user friendliness" of its data edit process
- the data base facility, providing the user with predefined building components
- low cost of use since data preparation and entry can be done quickly.

3.4 ENERPASS

PROGRAM:

ENERPASS (Version 1.1)

Program Authors:

Enermodal Engineering Ltd.,
421 King Street North,
Waterloo, Ontario N2J 4E4

PURPOSE:

ENERPASS was developed to simulate the energy used for space heating, cooling and domestic hot water in residential, small commercial or apartment buildings.

METHOD:

ENERPASS is a thermal network model. Heat flow equations are solved hourly. Building air and wall temperatures are recalculated every six minutes. (Version 1.2 uses a variable time step to calculate temperatures as the fixed time step can cause the program to be unstable under certain conditions.)

HARDWARE & RELATED SOFTWARE:

ENERPASS is written in FORTRAN 77 and is designed to be installed on any mini-computer or mainframe that can accommodate this version of FORTRAN.

Weather tapes may be purchased for approximately $100 from Enermodal Engineering or from the Atmospheric Environment Service (AES).

PROGRAM OPERATION:

The user creates new building description input files by using commands to edit existing files. The existing file may be the default file provided with the program or a previously defined user file.

At the start of the input procedure, the user is prompted to indicate which options are wanted, e.g. sunspace, insulating shutter, economics, etc. and this determines the nature of the default file provided to the user for editing. The analyst then uses commands (each has a one character abbreviation) to edit or list data, to save the input file, or to start calculations.

A flowchart of a typical modelling session is shown in Figure 3.4.1.

MAJOR PROGRAM FEATURES:

ENERPASS may simulate up to three zones (north, south and basement zone) with an additional zone that, if used, can be only specified as a sunspace. Zone to zone heat transfer can only be specified as an air flow rate. The user is limited to four vertical wall orientations (N, S, E & W) and a roof. The number of degrees the south wall is oriented off due south is entered. Only a sunspace surface may be defined as tilted (0-90 degrees).

The overall heat capacity of each zone is required input and is modelled as a "lumped" capacity. In the south zone only, supplementary mass (which can be specified as concrete, brick, stone, gypsum or a phase change material) is modelled independently and more explicitly than the "lumped" capacity.

The program is also capable of modelling; Trombe walls, waterwalls, window overhangs and window insulation and shading. The program closes a shade when the room temperature rises above a user specified value. ENERPASS assumes the window insulation is in place between sunset and sunrise.

Below grade loss is modelled using a method based on G.P. Mitalas basement heat loss studies (Reference 13). This model is potentially more accurate than models used in many other programs. The user specifies wall and floor insulation level and wall insulation depth. ENERPASS assumes all below grade walls lose their heat to ground (temperatures) at a depth of 10 cm and below grade floors at a depth of 300 cm. Minimum ground temperatures at 10 and 300 cm are required input (the documentation provides values for 16 Canadian locations).

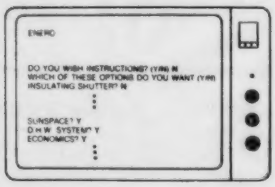
The program does not perform a detailed HVAC system simulation. The user defines a minimum and a maximum indoor temperature; a night setback temperature may also be specified. In addition the user may enter a seasonal furnace efficiency, a COP and an air-to-air heat exchanger effectiveness. The user may enter a ventilation rate, which is activated when the room air temperature exceeds the maximum indoor temperature.

ENERPASS models domestic hot water (DHW) heating systems. There are four heating system options available; a "standard" DHW heating system; an indoor air source heat pump heating an existing DHW tank; a heat pump heating a pre-heat tank; and a heat pump heating an existing DHW tank containing phase change pellets.

There are two levels of output available, monthly (and annual) and hourly results and the following information is output; solar energy (incident, transmitted, and net collected), auxiliary heating energy required (in each zone, and summed for entire building), auxiliary cooling energy (for the building) and the number of overheating hours. Domestic hot water data and economic analysis results are also output. (See figure 3.4.2 for typical output format.)

7 **DATA COLLECTION** EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATIONS" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS

13 **INPUT DATA PREPARATION** FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT THE DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM.



LOAD ENERPASS (SEE NOTE 1)

YES

CHOOSE THE APPROPRIATE OPTIONS

- REQUIRES A "Y" OR "N" RESPONSE TO NINE QUESTIONS

13:01

NO

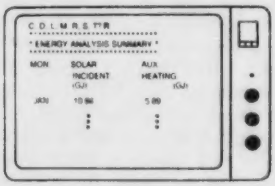
C D L M R S T ? L B1
B1 ABOVE GRADE BUILDINGS UA
ZONE DIR N GROSS
AREA (M2)
1 S 35
1 W 35
C D L M R S T ? C B115 22 B116 56
THE NUMBER OF CHANGES MADE = 2

MODIFY EXISTING FILE

- MAY BE THE DEFAULT FILE OR ANOTHER EXISTING FILE
- USE THE APPROPRIATE COMMANDS
  E.G. "L B1" - LIST SECTION B1
  "C B115 22 B116 .56"
  - CHANGES PARAMETERS B115 TO 22 AND B116 TO .56

13:46

NEW OPTIONS REQUIRED?

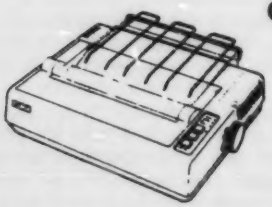


RUN PROGRAM

- E.G. R D 32, 60 SELECTS A DETAILED OUT (HOURLY RESULTS), PROGRAMS RUN FOR THE MONTH OF FEBRUARY (DAY 32 TO DAY 60)
- "R" - RUN PROGRAM FOR FULL YEAR (MONTHLY RESULTS)

13:51

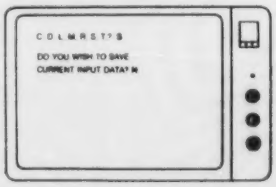
OUTPUT DATA — **PARAMETRIC RUNS REQUIRED?** — YES



13:52

NO

EXIT ENERPASS
— SAVE INPUT FILE IF REQUIRED

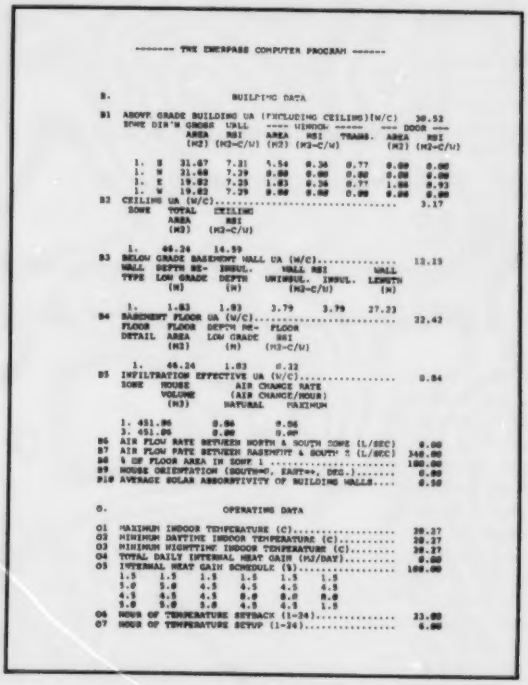


NOTES:

TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN. SEE APPENDIX D FOR DETAILS. THE FULL RANGE OF FEATURES AND DISPLAYED INFORMATION ARE OMITTED FOR CLARITY.

NOTE 1 - ASSUMES THAT ENERPASS AND THE APPROPRIATE WEATHER FILE HAS BEEN INSTALLED ON THE SYSTEM AND THE USER HAS ALREADY LOGGED ON.

FIGURE 3.4.1 ENERPASS - TYPICAL MODELLING SESSION



```
-------- THE ENERPASS COMPUTER PROGRAM -------

B.                    BUILDING DATA

B1  ABOVE GRADE BUILDING UA (EXCLUDING CEILING)(W/C)      30.52
    ZONE DIR'N GROSS  WALL      ---- WINDOW ------      --- DOOR ---
               AREA   RSI       AREA    RSI   TRANS.  AREA   RSI
               (M2) (M2-C/W)    (M2) (M2-C/W)          (M2) (M2-C/W)

     1.  S   31.67   7.31     4.54   0.36   0.77   0.00   0.00
     1.  W   31.48   7.29     0.00   0.00   0.00   0.00   0.00
     1.  E   19.82   7.25     1.83   0.36   0.77   1.86   0.93
     1.  W   19.82   7.29     0.00   0.00   0.00   0.00   0.00
B2  CEILING UA (W/C).....                                  3.17
    ZONE   TOTAL   CEILING
           AREA      RSI
           (M2)   (M2-C/W)

     1.    66.24    14.59
B3  BELOW GRADE BASEMENT WALL UA (W/C).....               12.15
    WALL   DEPTH BE-   INSUL.      WALL RSI          WALL
    TYPE   LOW GRADE   DEPTH    UNINSUL.   INSUL.   LENGTH
             (M)        (M)          (M2-C/W)         (M)

     1.     1.83       1.83        3.79       3.79    27.23
B4  BASEMENT FLOOR UA (W/C).....                          22.42
    FLOOR   FLOOR   DEPTH BE-   FLOOR
    DETAIL  AREA    LOW GRADE   RSI
            (M2)      (M)     (M2-C/W)

     1.    66.24      1.83      0.22
B5  INFILTRATION EFFECTIVE UA (W/C).....                   0.84
    ZONE    HOUSE          AIR CHANGE RATE
            VOLUME      (AIR CHANGE/HOUR)
              (M3)     NATURAL     MAXIMUM

    1. 451.86          0.86        0.86
    3. 451.86          0.00        0.00
B6  AIR FLOW RATE BETWEEN NORTH & SOUTH ZONE (L/SEC)       0.00
B7  AIR FLOW RATE BETWEEN BASEMENT & SOUTH 5 (L/SEC)     340.00
B8  % OF FLOOR AREA IN ZONE 1 .....                      100.00
B9  HOUSE ORIENTATION (SOUTH=0, EAST=+, DEG.).....        0.00
B10 AVERAGE SOLAR ABSORPTIVITY OF BUILDING WALLS....      0.50

O.                    OPERATING DATA

O1  MAXIMUM INDOOR TEMPERATURE (C).....                  20.27
O2  MINIMUM DAYTIME INDOOR TEMPERATURE (C).....          20.27
O3  MINIMUM NIGHTTIME INDOOR TEMPERATURE (C).....        20.27
O4  TOTAL DAILY INTERNAL HEAT GAIN (MJ/DAY).....          0.00
O5  INTERNAL HEAT GAIN SCHEDULE (%).....                100.00
    1.5   1.5   1.5   1.5   1.5   1.5
    5.0   5.0   4.5   4.5   4.5   4.5
    4.5   4.5   4.5   5.0   5.0   5.0
    5.0   5.0   5.0   4.5   4.5   1.5
O6  HOUR OF TEMPERATURE SETBACK (1-24).....              23.00
O7  HOUR OF TEMPERATURE SETUP (1-24).....                 6.00
```

FIGURE 3.4.2 ENERPASS - SAMPLE OUTPUT

```
C.                  THERMAL CAPACITY DATA

C1  HEAT CAPACITY OF ZONE 1 (MJ/C).....                   1.74
C2  HEAT CAPACITY OF ZONE 2 (MJ/C).....                   1.89
C3  HEAT CAPACITY OF BASEMENT (MJ/C).....                31.51
C4  % OF SOLAR RADIATION ABSORBED BY FURNITURE.....      20.00
C5  SURFACE AREA OF SOUTH ZONE INTERIOR WALLS (M2)..     74.41
C6  SURFACE AREA OF SOUTH HEAVY THERMAL MASS (M2)....     0.00
C7  THICKNESS OF HEAVY MASS (M).....                     15.00
C8  MAT'L: 1-CONCRETE,2-BRICK,3-STONE,4-GYP.,5-9.C..      3.00
C9  LATENT HEAT IN PHASE CHANGE MATERIAL (KJ/KG)....   252.00
C10 CHANGE OF PHASE TEMPERATURE (C).....                 25.00

H.              MECHANICAL SYSTEMS AND DESIGN DATA

H1  FUEL TYPE: 1 - ELEC., 2 - NAT. GAS, 3 - OIL ....     1.00
H2  SEASONAL FURNACE EFFICIENCY (%).....               100.00
H3  EFFECTIVENESS OF AIR-TO-AIR HEAT EXCHANGER.....      0.00
H4  HEAT EXCHANGER AIR FLOW RATE (L/SEC).....            0.00
H5  C.O.P. OF AIR CONDITIONING SYSTEM .....              0.00

R.              RADIATION REDUCTION DATA

R1  CODE: 1-DEPTH WINDOW OVERHANG, 2-REDUCED TRANS..     1.00
R2  WINDOW DIR'N 1-NTH, 2-STH, 3-EST, 4-WST, 5-ALL..     2.00
R3  OVERHANG PROJECTION SOUTH (M).....                   1.94
R4  OVERHANG PROJECTION EAST (M).....                    0.13
R5  OVERHANG PROJECTION WEST (M).....                    0.13
R6  TOP OF WINDOW TO OVERHANG DISTANCE (M).....          1.12
R7  AVERAGE SOUTH WINDOW HEIGHT (M).....                 1.93
R8  CHANGE IN TRANSMISSION TEMPERATURE (C).....         24.50
R9  REDUCED TRANSMISSION VALUE.....                      0.10

L.                  LOCATION DATA

L1  LOCATION AND LATITUDE (DEG).....OTTAWA              45.32
L2  YEAR OF WEATHER DATA.....                         1971.00
L3  YEARLY AVERAGE GROUND TEMPERATURE (C).....           8.90
L4  MINIMUM GROUND TEMPERATURE AT 10 CM DEPTH (C)...     0.00
L5  MINIMUM GROUND TEMPERATURE AT 300 CM DEPTH (C)..     4.60
```

```
                    ENERGY ANALYSIS SUMMARY

| MON | SOLAR INCIDENT (GJ) | SOLAR TRANS. (GJ) | SOLAR COLLECT (GJ) | AUX. ZONE 1 (GJ) | AUX. ZONE 2 (GJ) | AUX. BASMNT (GJ) | AUX. HEATING (GJ) | COOLING ENERGY (GJ) | OVER-HEATING HOURS |
|---|---|---|---|---|---|---|---|---|---|
| JAN | 2.30 | 1.59 | -0.87 | 2.63 | 0.00 | 0.85 | 3.48 | 0.00 | 159 |
| FEB | 1.92 | 1.32 | 0.04 | 1.95 | 0.00 | 0.97 | 2.93 | 0.00 | 134 |
| MAR | 3.42 | 2.24 | 0.99 | 1.45 | 0.00 | 0.77 | 2.23 | 0.00 | 251 |
| APR | 3.67 | 1.54 | 0.69 | 0.99 | 0.00 | 0.00 | 1.00 | 0.00 | 275 |
| MAY | 2.26 | 0.92 | 0.54 | 0.40 | 0.00 | 0.00 | 1.35 | 0.00 | 393 |
| JUN | 2.62 | 1.00 | 0.06 | 0.13 | 0.00 | 0.34 | 0.47 | 0.00 | 552 |
| JUL | 2.29 | 0.98 | 0.00 | 0.05 | 0.00 | 0.06 | 0.10 | 0.00 | 662 |
| AUG | 2.35 | 1.07 | 0.00 | 0.07 | 0.00 | 0.05 | 0.13 | 0.00 | 647 |
| SEP | 1.94 | 1.23 | 0.04 | 0.06 | 0.00 | 0.01 | 0.06 | 0.00 | 647 |
| OCT | 1.95 | 1.00 | 0.05 | 0.01 | 0.00 | 0.15 | 0.07 | 0.00 | 357 |
| NOV | 1.39 | 0.94 | -0.07 | 1.63 | 0.00 | 0.01 | 1.04 | 0.00 | 143 |
| DEC | 1.91 | 1.00 | -0.31 | 2.33 | 0.00 | 0.00 | 2.02 | 0.00 | 117 |
| YR | 26.01 | 14.94 | 0.92 | 12.25 | 0.00 | 4.11 | 10.36 | 0.00 | 4389 |

TOTAL ENERGY CONSUMPTION OVER SIMULATION PERIOD

HEATING : IN GJ      10.36      IN KWH      2899.09

** NUMBER OF HOURS THAT BUILDING OVERHEATS : 4389

** MAXIMUM ENERGY INPUT (KW):    2.66
```

ACCURACY:

Figure 3.4.3 shows good agreement between the energy consumption calculated by ENERPASS and the measured values.

Hour-by-hour comparisons indicate that the results tend to lag the measured energy consumption. In addition calculated zone temperatures were too high in the south zone and too low in the north zone, suggesting a problem with the modelling interzone heat transfer.

The simulation of the sunspace test cell resulted in program instability when calculating room temperature. We understand that this problem no longer exists in Version 1.2.

PROGRAM ACCURACY
ENERPASS

■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
● -NRC TOMBE WALL TEST CELL
□ -NRC SUNSPACE TEST CELL
△ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

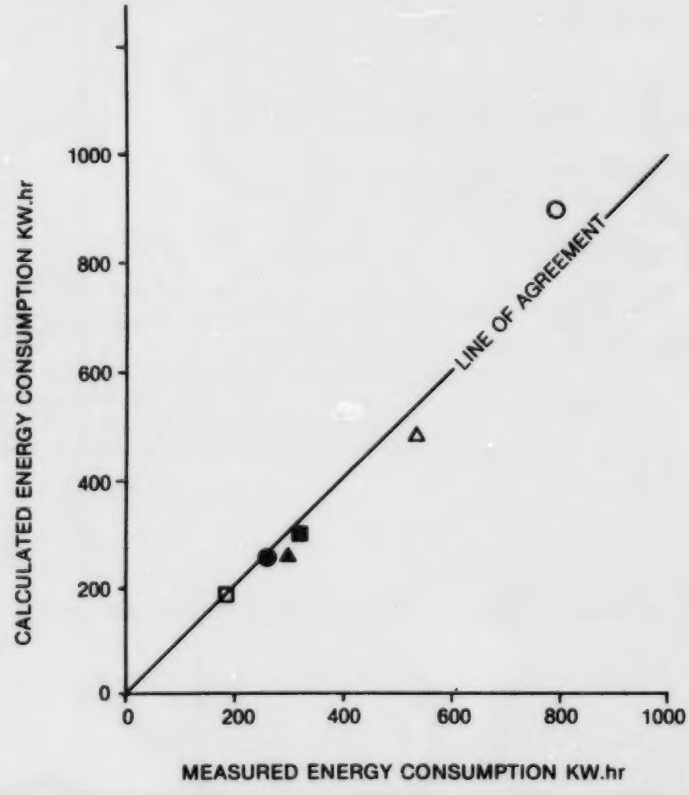


FIGURE 3.4.2 ENERPASS - PROGRAM ACCURACY

EASE OF USE:

The user can quickly learn the seven commands required to enter and display data and run the program. Multiple responses are allowed on the same line but this can be awkward and confusing at times. This is particularly the case when the user must make changes to specific values in an input matrix (i.e. where the user must specify the row and column number). Much of the "Building Data" section (i.e. the descriptions - walls, window, roofs, etc.) is in a matrix form.

Input errors often result in brief and sometimes unclear messages. Some responses can cause the program to crash (thus losing all previous input). An error, occurring when data is entered as multiple responses will result in the loss of all subsequent data on that specific line. There are instances where accepted input data will cause the program to crash during the calculations, due to instability. The resulting error messages are meaningless to the general user. In some cases the program will be part way through the simulation before crashing, resulting in computation charges.

The manual is easy to read but it could be better organized. It also lacks in content. The following should be provided:

- greater discussion of the capabilities and limitations of algorithms and computation procedures;

- more reference information, better explanations and advice on the calculation or selection of each input parameter;

- explanation of error messages;

- hardware requirements and software installation descriptions.

The program has no easy method to save and restore input files (the user must exit the program before he is prompted to save the data). Also, the user can only save multiple input files by using the computer operating system - this procedure is not mentioned in the documentation.

CONCLUSIONS & GENERAL COMMENTS:

In terms of technical scope and accuracy, ENERPASS appears to be a potentially useful design tool for modelling passive solar residential designs (especially if the problem of instability resulting in the program crashing has been solved in the new version). The program is, however, moderately expensive to use (typically $25 for full year simulation).

The weakness of ENERPASS lies in its lack of "user friendliness". There are no meaningful error messages; no easy method to store multiple input files; awkward data entry/edit procedures; lack of adequate input checking and inadequate parameter descriptions in the documentation.

We understand that Version 1.2 has improved error checking, data entry/edit and data saving/restoring procedures. There is also a more detailed and descriptive user's manual provided.

3.5 F-LOAD

PROGRAM:

F-LOAD (Version 5.1)
Program Authors:

Beckman, Duffie and Associates
4406 Fox Bluff Road
Middleton, Wisconsin 53762

PURPOSE:

F-LOAD is designed to model the thermal performance and economics of conservation and passive strategies of single zone buildings.

METHOD:

The program uses an ASHRAE degree-day method to calculate the monthly energy consumption. This method is modified by a procedure (developed by NBS-National Bureau of Standards) to account for the energy storage in the structure. A balance temperature, from which the degree-days are based, is calculated from the combination of heat (internal and solar) gains and variable thermostat settings, i.e. night setback. The heating and cooling equipment performance is modelled using a bin method. The building load, and the equipment capacity and efficiency are calculated for the midpoint temperature in each bin.

HARDWARE & RELATED SOFTWARE:

This evaluation was based on the IBM-PC version of F-LOAD. Versions for Apple II (II/Plus and II/E), TRS-80 and CP/M are also available.

F-LOAD is written in BASIC and the disk is not protected thus the user may view the code and make changes. However, the program is not written such that the user can make changes easily and the program authors do not encourage this practice.

The program requires a minimum of 64K RAM and one disk drive; a printer is recommended.

PROGRAM OPERATION:

The user creates new building description and equipment description files by editing existing files (one of which contains the default values for each parameter). Data are entered in by typing the parameter number and then the value. This process can be a bit awkward and slow. "Write-over" tables (full screen editing) would be easier. Data input sheets are provided and are necessary since the above method of data entry means there is no prompting for data.

Figure 3.5.1 outlines a typical modelling session.

MAJOR PROGRAM FEATURES:

F-LOAD can model night setback, night insulation, storage (Trombe) walls, below grade surfaces, unheated garages, domestic hot water energy consumption, equipment performance, and ventilation with heat recovery.

The user may specify overhangs (assumed to be infinitely wide) for one window and/or a collector-storage wall. The input parameter WINDOW % OF TIME SHADED allows the user to enter a factor to account for the reduction in incident solar energy due to shading.

An index indicating a building of standard, medium-weight or heavy-weight construction or an effective building capacity per floor area may be entered. It is not clear, however, how F-LOAD calculates floor area as it is not an input parameter.

Equipment performance is simulated. The user is required to specify up to 10 data points relating; equipment capacity to outside air temperature; equipment efficiency to outside air temperature; and an equipment part load factor to the load/capacity ratio. Default data points are given for the following; electric resistance heating, hot air furnace, boiler, heat pump, and electric and fuel-fired air conditioners.

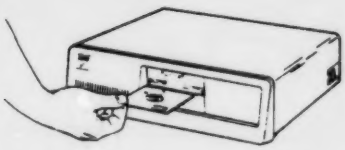
Optionally, F-LOAD carries out an economic analysis when fuel tarrifs and other financial data are entered. Annual fuel costs, life cycle costs and a breakdown of expenses and tax credits are calculated.

Weather data files are available for 329 North American (including 93 Canadian) locations. This represented the most extensive Canadian weather data base of the programs tested.

F-LOAD allows the user to select one of four levels of output. The levels range from annual totals of heating and cooling energy consumption, to a breakdown of energy consumption by component and month, which are tabulated and plotted. Special graphics cards or a special printer/plotter, are not required. (Figure 3.5.2 shows typical output tables.)

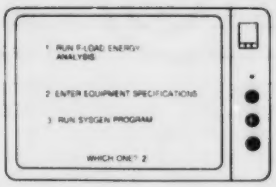
7 **DATA COLLECTION** EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATIONS" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS

7:30 **INPUT DATA PREPARATION** FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM.

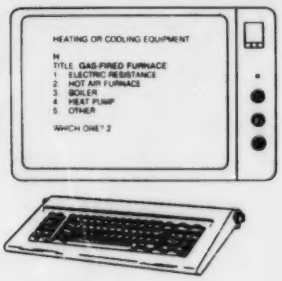


INSERT PROGRAM AND WORKING DISKS IN DISK DRIVES, TURN ON MACHINE:

SELECT EQUIPMENT SPECIFICATIONS PROGRAM (SEE NOTE 1.)



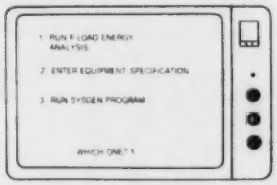
ENTER EQUIPMENT DESCRIPTION

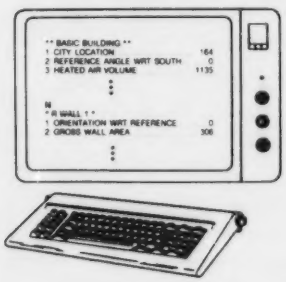


— SAVE FILE
— REPEAT FOR COOLING EQUIPMENT (IF APPLICABLE)

7:35 (SEE NOTE 2)

SELECT F-LOAD PROGRAM




** BASIC BUILDING **
1 CITY LOCATION 164
2 REFERENCE ANGLE WRT SOUTH 0
3 HEATED AIR VOLUME 1135
N
** R WALL 1 **
1 ORIENTATION WRT REFERENCE 0
2 GROSS WALL AREA 306

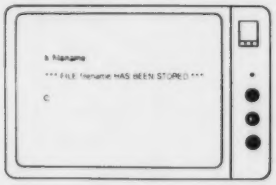
ENTER BUILDING DESCRIPTION

- USING THE APPROPRIATE COMMANDS THE USER MAY ENTER, DISPLAY AND AND EDIT DATA: ALSO SAVE AND RECALL FILES.
- CHECKS FOR UNACCEPTABLE DATA ARE PERFORMED AS DATA IS ENTERED
- "N" IS AN ABBREVIATED COMMAND FOR NEXT DISPLAY

7:55

SAVE INPUT FILE

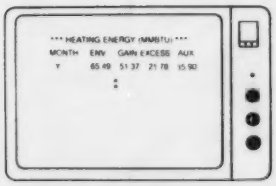
- "K" IS AN ABBREVIATED COMMAND FOR KEEP



"RUN" PROGRAM

- "c" IS AN ABBREVIATED COMMAND FOR CALCULATE

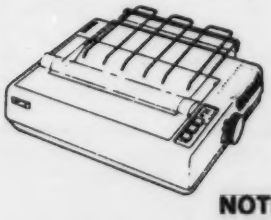
8:05



OUTPUT DATA

— OUTPUT MAY BE VIEWED FROM THE SCREEN OR PRINTED OFF.

8:07

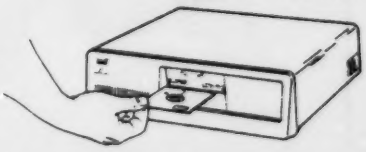


ADDITIONAL RUNS REQUIRED?

YES

NO

REMOVE DISKS



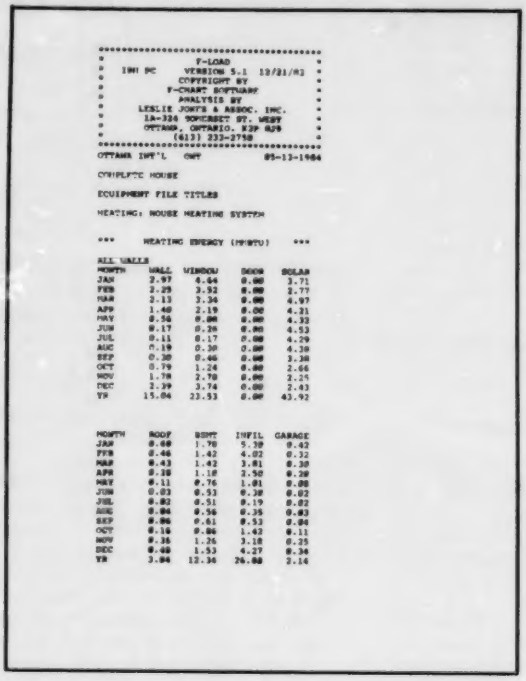
NOTES:

TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN. SEE APPENDIX D FOR DETAILS.
THE FULL RANGE OF FEATURES AND DISPLAYED INFORMATION ARE OMITTED FOR CLARITY.

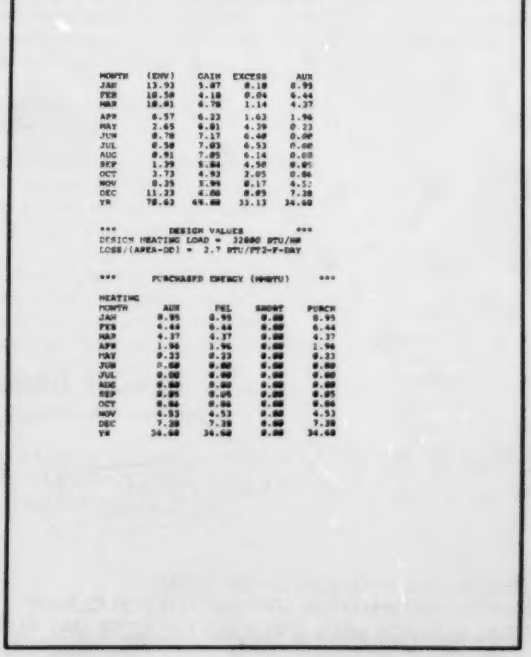
NOTE 1 - IF THE APPROPRIATE EQUIPMENT HAS ALREADY BEEN SPECIFIED THE USER MAY RUN THE F-LOAD ANALYSIS.
- SYSGEN IS NORMALLY ONLY RUN ONCE PER SYSTEM TYPE (E.G. IBM-PC, APPLE, ETC.)

NOTE 2 - LONGER IF DEFAULT PERFORMANCE CURVES ARE NOT USED

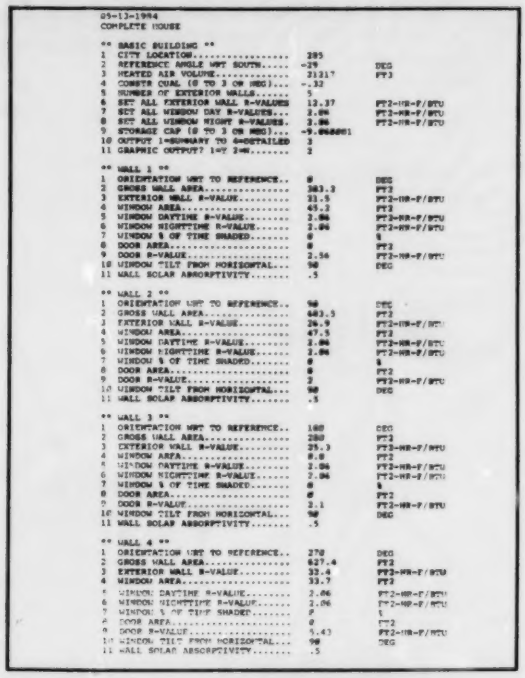
FIGURE 3.5.1 F-LOAD - TYPICAL MODELLING SESSION



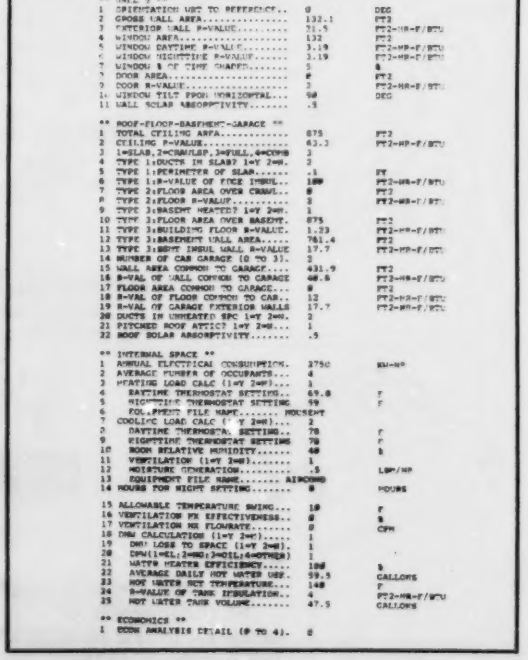
```
**********************************
*                                *
*            F-LOAD              *
*         VERSION 5.1  12/21/83  *
*      COPYRIGHT BY              *
*    F-CHART SOFTWARE            *
*      ANALYSIS BY               *
*  LESLIE JONES & ASSOC. INC.    *
*    1A-324 SOMERSET ST. WEST    *
*    OTTAWA, ONTARIO. K2P 0J9    *
*        (613) 233-2758          *
**********************************
OTTAWA INT'L   CWT              05-13-1984

CYMPLETC HOUSE

ECUIPMENT FILE TITLES

HEATING: HOUSE HEATING SYSTEM

***     HEATING ENERGY (MMBTU)     ***

ALL WALLS
MONTH     WALL    WINDOW     DOOR     SOLAR
JAN       2.97      4.64     0.00      3.71
FEB       2.25      3.52     0.00      2.77
MAR       2.13      3.34     0.00      4.97
APR       1.40      2.19     0.00      4.31
MAY       0.56      0.88     0.00      4.33
JUN       0.17      0.26     0.00      4.53
JUL       0.11      0.17     0.00      4.29
AUG       0.19      0.30     0.00      4.38
SEP       0.30      0.46     0.00      3.38
OCT       0.79      1.24     0.00      2.66
NOV       1.78      2.78     0.00      2.24
DEC       2.39      3.74     0.00      2.43
YR       15.04     23.53     0.00     43.92


MONTH     ROOF      BSMT     INFIL   GARAGE
JAN       0.68      1.76      5.38     0.62
FEB       0.46      1.42      4.02     0.32
MAR       0.43      1.42      3.81     0.30
APR       0.28      1.18      2.58     0.20
MAY       0.11      0.76      1.01     0.08
JUN       0.03      0.53      0.38     0.02
JUL       0.02      0.51      0.19     0.02
AUG       0.04      0.56      0.35     0.03
SEP       0.06      0.61      0.53     0.04
OCT       0.16      0.86      1.42     0.11
NOV       0.35      1.26      3.18     0.25
DEC       0.48      1.53      4.27     0.34
YR        3.04     12.34     26.86     2.14
```



```
MONTH     (ENV)     GAIN   EXCESS      AUX
JAN       13.93     5.87     0.10     8.95
FEB       10.58     4.18     0.04     6.44
MAR       10.81     6.78     1.14     4.37

APR        6.57     6.23     1.63     1.96
MAY        2.65     6.81     4.39     0.23
JUN        0.79     7.17     6.49     0.00
JUL        0.58     7.03     6.53     0.00
AUG        0.91     7.05     6.14     0.00
SEP        1.39     5.84     4.58     0.85
OCT        3.73     4.93     2.05     0.86
NOV        8.35     5.96     0.17     4.52
DEC       11.23     4.00     0.85     7.28
YR        70.63    69.88    33.13    34.68

***          DESIGN VALUES          ***
DESIGN HEATING LOAD =   32880 BTU/HR
LOSS/(AREA-DD) =  2.7 BTU/FT2-F-DAY

***     PURCHASED ENERGY (MMBTU)     ***

HEATING
MONTH     AUX       FEL      SHORT     PURCH
JAN       8.95      8.95     0.00      8.95
FEB       6.44      6.44     0.00      6.44
MAR       4.37      4.37     0.00      4.37
APR       1.96      1.96     0.00      1.96
MAY       0.23      0.23     0.00      0.23
JUN       0.00      0.00     0.00      0.00
JUL       0.00      0.00     0.00      0.00
AUG       0.00      0.00     0.00      0.00
SEP       0.85      0.85     0.00      0.85
OCT       0.86      0.86     0.00      0.86
NOV       4.53      4.53     0.00      4.53
DEC       7.28      7.28     0.00      7.28
YR       34.68     34.68     0.00     34.68
```



```
05-13-1984
COMPLETE HOUSE

** BASIC BUILDING **
1  CITY LOCATION.................  285
2  REFERENCE ANGLE WRT SOUTH.....  -29              DEG
3  HEATED AIR VOLUME.............  21217            FT3
4  CONSTR CUAL (0 TO 3 OR MSG)...  -.32
5  NUMBER OF EXTERIOR WALLS......  5
6  SET ALL EXTERIOR WALL R-VALUES  12.37            FT2-HR-F/BTU
7  SET ALL WINDOW DAY R-VALUES...  2.86             FT2-HR-F/BTU
8  SET ALL WINDOW NIGHT R-VALUES.  2.86             FT2-HR-F/BTU
9  STORAGE CAP (0 TO 3 OR MSG)...  -9.0E+001
10 OUTPUT 1=SUMMARY TO 4=DETAILED  3
11 GRAPHIC OUTPUT? 1=Y 2=N.......  2

** WALL 1 **
1  ORIENTATION WRT TO REFERENCE..  0                DEG
2  GROSS WALL AREA...............  383.3            FT2
3  EXTERIOR WALL R-VALUE.........  21.5             FT2-HR-F/BTU
4  WINDOW AREA...................  45.2             FT2
5  WINDOW DAYTIME R-VALUE........  2.86             FT2-HR-F/BTU
6  WINDOW NIGHTTIME R-VALUE......  2.86             FT2-HR-F/BTU
7  WINDOW % OF TIME SHADED.......  0                %
8  DOOR AREA.....................  0                FT2
9  DOOR R-VALUE..................  2.56             FT2-HR-F/BTU
10 WINDOW TILT FROM HORIZONTAL...  90               DEG
11 WALL SOLAR ABSORPTIVITY.......  .5

** WALL 2 **
1  ORIENTATION WRT TO REFERENCE..  90               DEG
2  GROSS WALL AREA...............  483.5            FT2
3  EXTERIOR WALL R-VALUE.........  26.9             FT2-HR-F/BTU
4  WINDOW AREA...................  47.5             FT2
5  WINDOW DAYTIME R-VALUE........  2.86             FT2-HR-F/BTU
6  WINDOW NIGHTTIME R-VALUE......  2.86             FT2-HR-F/BTU
7  WINDOW % OF TIME SHADED.......  0                %
8  DOOR AREA.....................  0                FT2
9  DOOR R-VALUE..................  2                FT2-HR-F/BTU
10 WINDOW TILT FROM HORIZONTAL...  90               DEG
11 WALL SOLAR ABSORPTIVITY.......  .5

** WALL 3 **
1  ORIENTATION WRT TO REFERENCE..  180              DEG
2  GROSS WALL AREA...............  280              FT2
3  EXTERIOR WALL R-VALUE.........  25.3             FT2-HR-F/BTU
4  WINDOW AREA...................  8.0              FT2
5  WINDOW DAYTIME R-VALUE........  2.86             FT2-HR-F/BTU
6  WINDOW NIGHTTIME R-VALUE......  2.86             FT2-HR-F/BTU
7  WINDOW % OF TIME SHADED.......  0                %
8  DOOR AREA.....................  0                FT2
9  DOOR R-VALUE..................  2.1              FT2-HR-F/BTU
10 WINDOW TILT FROM HORIZONTAL...  90               DEG
11 WALL SOLAR ABSORPTIVITY.......  .5

** WALL 4 **
1  ORIENTATION WRT TO REFERENCE..  270              DEG
2  GROSS WALL AREA...............  627.4            FT2
3  EXTERIOR WALL R-VALUE.........  33.4             FT2-HR-F/BTU
4  WINDOW AREA...................  33.7             FT2
5  WINDOW DAYTIME R-VALUE........  2.86             FT2-HR-F/BTU
6  WINDOW NIGHTTIME R-VALUE......  2.86             FT2-HR-F/BTU
7  WINDOW % OF TIME SHADED.......  0                %
8  DOOR AREA.....................  0                FT2
9  DOOR R-VALUE..................  5.43             FT2-HR-F/BTU
10 WINDOW TILT FROM HORIZONTAL...  90               DEG
11 WALL SOLAR ABSORPTIVITY.......  .5
```



```
** WALL 5 **
1  ORIENTATION WRT TO REFERENCE..  0                DEG
2  GROSS WALL AREA...............  132.1            FT2
3  EXTERIOR WALL R-VALUE.........  21.5             FT2-HR-F/BTU
4  WINDOW AREA...................  133              FT2
5  WINDOW DAYTIME R-VALUE........  3.19             FT2-HR-F/BTU
6  WINDOW NIGHTTIME R-VALUE......  3.19             FT2-HR-F/BTU
7  WINDOW % OF TIME SHADED.......  0                %
8  DOOR AREA.....................  0                FT2
9  DOOR R-VALUE..................  3                FT2-HR-F/BTU
10 WINDOW TILT FROM HORIZONTAL...  90               DEG
11 WALL SOLAR ABSORPTIVITY.......  .5

** ROOF-FLOOR-BASEMENT-GARAGE **
1  TOTAL CEILING AREA............  875              FT2
2  CEILING R-VALUE...............  43.3             FT2-HR-F/BTU
3  1=SLAB,2=CRAWLSP,3=FULL.4=CVHB  3
4  TYPE 1:DUCTS IN SLAB? 1=Y 2=N.  2
5  TYPE 1:PERIMETER OF SLAB......  .1               FT
6  TYPE 1:R-VALUE OF EDGE INSUL..  189              FT2-HR-F/BTU
7  TYPE 2:FLOOR AREA OVER CRAWL..  0                FT2
8  TYPE 2:FLOOR R-VALUE..........  0                FT2-HR-F/BTU
9  TYPE 3:BASEMT HEATED? 1=Y 2=N.  1
10 TYPE 3:FLOOR AREA OVER BASEMT.  875              FT2
11 TYPE 3:BUILDING FLOOR R-VALUE.  1.23             FT2-HR-F/BTU
12 TYPE 3:BASEMENT WALL AREA.....  761.4            FT2
13 TYPE 3:BSMT INSUL WALL R-VALUE  17.7             FT2-HR-F/BTU
14 NUMBER OF CAR GARAGE (0 TO 3).  2
15 WALL AREA COMMON TO GARAGE....  431.9            FT2
16 R-VAL OF WALL COMMON TO GARAGE  48.8             FT2-HR-F/BTU
17 FLOOR AREA COMMON TO GARAGE...  0                FT2
18 R-VAL OF FLOOR COMMON TO CAR..  12               FT2-HR-F/BTU
19 R-VAL OF GARAGE EXTERIOR WALLS  17.7             FT2-HR-F/BTU
20 DUCTS IN UNHEATED SPC 1=Y 2=N.  2
21 PITCHED ROOF ATTIC? 1=Y 2=N...  1
22 ROOF SOLAR ABSORPTIVITY.......  .9

** INTERNAL SPACE **
1  ANNUAL ELECTRICAL CONSUMPTION.  3750             KW-HR
2  AVERAGE NUMBER OF OCCUPANTS...  4
3  HEATING LOAD CALC (1=Y 2=N)...  1
4    DAYTIME THERMOSTAT SETTING..  69.8             F
5    NIGHTTIME THERMOSTAT SETTING  59               F
6    FOR..FFSET FILE NAME.....  HOUSEHT
7  COOLING LOAD CALC (1=Y 2=N)...  2
8    DAYTIME THERMOSTAT SETTING..  78               F
9    NIGHTTIME THERMOSTAT SETTING  78               F
10   ROOM RELATIVE HUMIDITY......  48               %
11   VENTILATION (1=Y 2=N).......  1
12   MOISTURE GENERATION.........  .5               LBM/HR
13   EQUIPMENT FILE NAME.....  AIRCOND
14 HOURS FOR NIGHT SETTING.......  8                HOURS

15 ALLOWABLE TEMPERATURE SWING...  10               F
16 VENTILATION HX EFFECTIVENESS..  0                %
17 VENTILATION HX FLOWRATE......   0                CFM
18 DHW CALCULATION (1=Y 2=N)....   1
19   DHW LOSS TO SPACE (1=Y 2=N).  1
20   DFW(1=ELL,2=NG,3=OIL,4=OTHER  1
21   WATER HEATER EFFICIENCY.....  100              %
22   AVERAGE DAILY HOT WATER USE.  59.5             GALLONS
23   HOT WATER SET TEMPERATURE...  140              F
24   R-VALUE OF TANK INSULATION..  4                FT2-HR-F/BTU
25   HOT WATER TANK VOLUME.......  47.5             GALLONS

** ECONOMICS **
1  ECON ANALYSIS DETAIL (0 TO 4).  0
```

FIGURE 3.5.2 F-LOAD - SAMPLE OUTPUT

PROGRAM ACCURACY

F-LOAD

- ■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
- ▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
- ● -NRC TOMBE WALL TEST CELL
- □ -NRC SUNSPACE TEST CELL
- △ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
- ○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

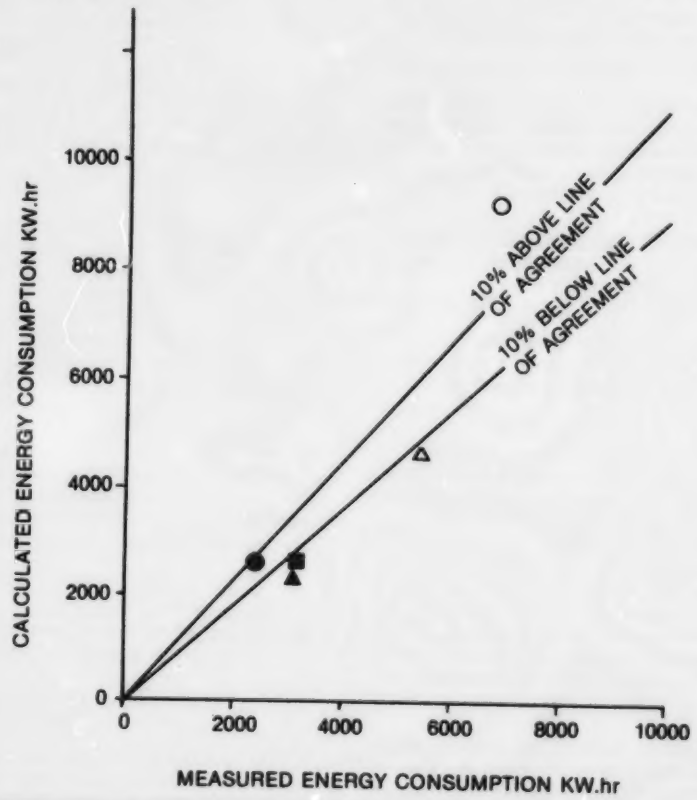


FIGURE 3.5.3 F-LOAD - PROGRAM ACCURACY

ACCURACY:

F-LOAD produced results for the NRC Lightweight, Trombe Wall and Alberta Energy Conservation test cells that were consistent with the corresponding estimated annual energy consumption (Figure 3.5.3). Examination of monthly totals revealed that for the Trombe Wall test cell, the program over-estimated the auxiliary energy requirement in the spring and fall months.

Less consistent results were obtained for the NRC Heavyweight test cell possibly due to the simplified method of estimating thermal capacity incorporated by F-LOAD. The results for Alberta Passive Solar module were also not consistent with expected results.

There is no facility in F-LOAD to model sunspaces (the program only models single zone buildings) thus the NRC Sunspace test cell was not simulated.

EASE OF USE:

Initially the new user may find F-LOAD a little confusing to learn (a better introduction with program outline would help), but once the user has made a few simulations the program becomes easy to use. Error checking procedures are not discussed and error messages are brief, non-descriptive and are not listed in the documentation. The use of the cursor-arrow keys when editing data will cause the program to crash and commands typed in lower case are sometimes ignored.

The documentation was easy to read and understand, although a new user would find a better introduction with a program outline an asset. Also, a list of error messages would be helpful, some are mentioned but they are scattered through the documentation. Most methods and equations are identified, referenced and explained, but their capabilities and limitations are generally not discussed. There is generally enough information provided in the documentation for a user, knowledgeable in thermodynamics and heat transfer, to realize the major capabilities and limitations of each method.

Graphical representation of the output (i.e. plotted bar graphs) are appreciated, although several parametric results plotted together would be better (this feature was generally not available in the programs tested). The meanings of some output headings are not readily apparent (e.g. under the "PURCHASED ENERGY" heading are the subheadings "AUX", "DEL", "SHORT" and "PURCH"). The user must reference the manual for the meanings.

CONCLUSIONS & GENERAL COMMENTS:

F-LOAD provides limited flexibility to describe buildings and cannot model some passive solar features (e.g. attached sunspaces). In contrast the program has great flexibility to model various heating and cooling equipment. This feature was not provided in any of the other programs tested.

Initially the new user may find the program confusing, but after a few simulations this is not a concern. Improved documentation, with a better introduction and program outline, and with error messages listed and explained would help.

Other program strengths are the extensive weather data base (with 93 Canadian locations) and the output bar graphs which allow for a quick visual analysis of the results.

Overall F-LOAD provides the user with an inexpensive, easy and quick way to model many applications.

3.6 HOTCAN

PROGRAM:

HOTCAN (Version 2.0 - Release 4.01)
Original Program Authors:

R.S. Dumont, M.E. Lux and H.W. Orr,
Division of Building Research,
National Research Council.

- Modifications by Supporting Agency

Supporting Agency:

Energy, Mines and Resources,
Office of Conservation,
(613) 995-1118.

PURPOSE:

HOTCAN was developed primarily to model single zone low energy houses.

METHOD:

Average daily heat losses are calculated using the monthly average outdoor temperature, for above grade surfaces (transmission through walls, windows, roofs, etc.), and for infiltration and ventilation. Below grade heat losses are calculated based on the method developed by G.P. Mitalas (Reference 8).

Average daily solar heat gains are calculated using values of solar radiation incident on a vertical surface facing in each of the four cardinal directions plus southeast and southwest.

Monthly energy consumption is calculated based on techniques developed by S.A. Barakat and D.M. Sanders (References 4 & 5).

HARDWARE & RELATED SOFTWARE:

There are several versions of HOTCAN that can run on several microcomputers (North Star, Apple, TRS-80 and IBM-PC). The program requires 24 to 64K RAM (depending on the version), two disk drives and a printer. It is written in BASIC and requires the computer's disk operating system software.

Since the program is not protected the user may view the code. The code is fairly readable, but would benefit if indentations and more comments were provided.

This evaluation is based on the version of HOTCAN that runs on a North Star Advantage microcomputer.

NOTE: HOTCAN was developed on an Apple II, then adapted to the North Star. Many of the details in this review are specific to the North Star (i.e. 64K RAM Pie/bar chart output, cost $55, multiple run comparisons documentation).

PROGRAM OPERATION:

The program is menu driven. When the appropriate selection has been made then the program prompts the user to enter all the information necessary to carry out a simulation.

A typical modelling session flowchart is shown in Figure 3.6.1.

MAJOR PROGRAM FEATURES:

HOTCAN was designed to estimate the heating requirements of single zone buildings, cooling requirements are not addressed.

The program is not particularly orientated towards passive solar design as only direct gain strategies may be modelled. Window glass areas can be entered for six orientations (N, S, E, W, SE & SW). Overhangs (assumed to be infinite in length) and window insulation can be specified only on the south, southeast or southwest facing windows. The window insulation calculation did not work in the copy of HOTCAN that was tested.

HOTCAN does not account for absorbed solar radiation on exterior wall surfaces. Total net wall area (for all orientations) is entered as a single value.

The user may choose from building weights of light, medium, heavy or very heavy construction.

The user enters the daily hot water consumption which is included in the output of total consumption.

HOTCAN does not perform a system simulation. However, a mechanical ventilation air exchange rate and a heat recovery effectiveness may be entered. HOTCAN cannot model a night setback strategy.

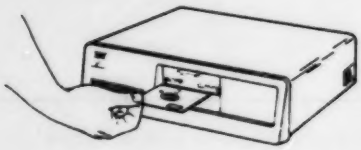
Weather data are available for 68 Canadian locations. All provinces and territories are represented.

HOTCAN outputs an echo of all input parameters, design heat loss and an average daily value of thermal load, solar fraction, auxiliary heat energy consumption and total energy consumption (includes electric and hot water) for each month. (Figure 3.6.2 shows typical output.) Annual summaries of energy consumption and fuel cost are also output. Optionally a user may output graphics; a piechart of component heat loss and a bar chart of monthly energy consumption. A comparison of two simulations may be output on the same bar chart.

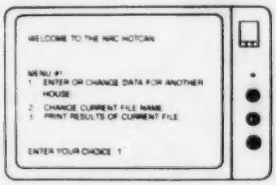
HOTCAN has a feature which allows the user to enter tax rates, fuel escalation rates, and mortgage details. The program outputs a comparison of the monthly payments of two models.

DATA COLLECTION EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATION" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS. 7

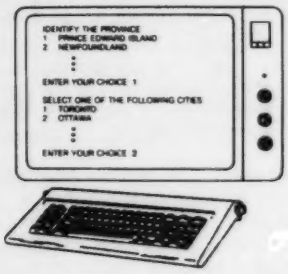
INPUT DATA PREPARATION FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT THE DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM. 7:30



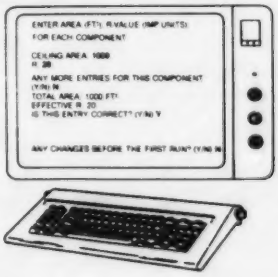
INSERT PROGRAM AND WORKING DISK IN DISK DRIVES, TURN ON MACHINE:
(SEE NOTE 1)


WELCOME TO THE NRC HOTCAN
MENU #1
1. ENTER OR CHANGE DATA FOR ANOTHER HOUSE
2. CHANGE CURRENT FILE NAME
3. PRINT RESULTS OF CURRENT FILE
ENTER YOUR CHOICE 1

SELECT APPROPRIATE OPTION FROM MAIN MENU (OPTION 1 ENTER... DATA FOR ANOTHER HOUSE)

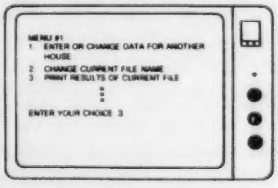


SELECT WEATHER FILE

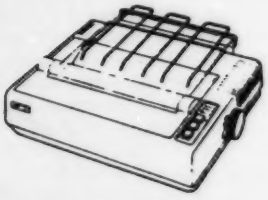

ENTER AREA (FT²), R-VALUE (IMP UNITS)
FOR EACH COMPONENT
CEILING AREA 1000
R 20
ANY MORE ENTRIES FOR THIS COMPONENT (Y/N) N
TOTAL AREA 1000 FT²
EFFECTIVE R 20
IS THIS ENTRY CORRECT? (Y/N) Y
ANY CHANGES BEFORE THE FIRST RUN? (Y/N) N

ENTER BUILDING DESCRIPTION
THE USER IS PROMPTED FOR ALL INPUT INFORMATION

7:45


MENU #1
1. ENTER OR CHANGE DATA FOR ANOTHER HOUSE
2. CHANGE CURRENT FILE NAME
3. PRINT RESULTS OF CURRENT FILE
ENTER YOUR CHOICE 3

SELECT APPROPRIATE OPTION FROM MAIN MENU (OPTION 3 PRINT RESULTS OF CURRENT FILE)



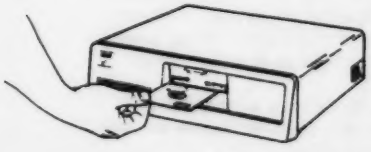
- THE SELECTION FIRST CALCULATES ENERGY CONSUMPTION ETC., THEN PRINTS THE OUTPUT.

OPTION 1 - CHANGE DATA FOR ANOTHER HOUSE

7:47

SELECT APPROPRIATE OPTION FROM MAIN MENU

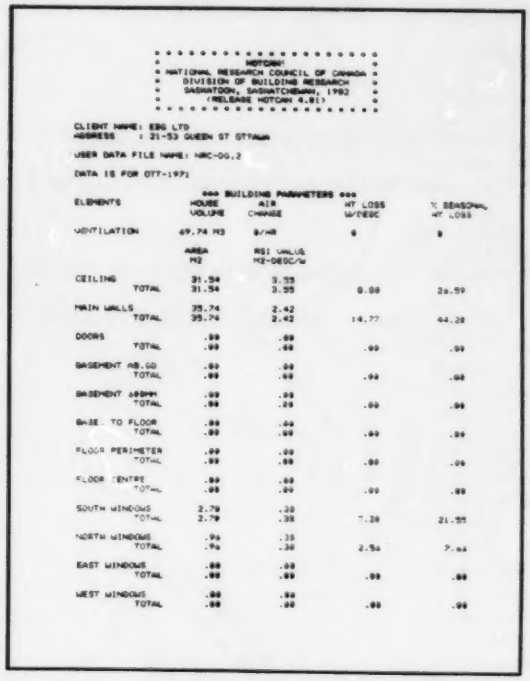
OPTION 9 - END SESSION



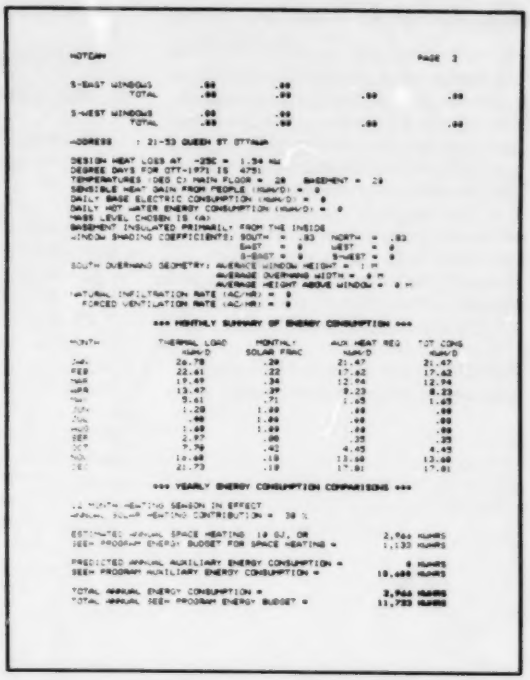
REMOVE DISKS

NOTES:
TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN SEE APPENDIX 4 FOR DETAILS.
THE FULL RANGE OF FEATURES AND DISPLAYED INFORMATION ARE OMITTED FOR CLARITY.
NOTE 1 - ASSUMES DISK OPERATING SYSTEM COMMANDS HAVE BEEN COPIED ONTO PROGRAM DISC.

FIGURE 3.6.1 HOTCAN - TYPICAL MODELLING SESSION



```
                    HOTCAN
          NATIONAL RESEARCH COUNCIL OF CANADA
            DIVISION OF BUILDING RESEARCH
            SASKATOON, SASKATCHEWAN, 1982
              (RELEASE HOTCAN 4.01)

CLIENT NAME: ERG LTD
ADDRESS    : 21-53 QUEEN ST OTTAWA

USER DATA FILE NAME: NRC-00.2

DATA IS FOR OTT-1971

                    *** BUILDING PARAMETERS ***
ELEMENTS            HOUSE VOLUME   AIR CHANGE   HT LOSS W/DEGC   % SEASONAL HT LOSS
VENTILATION         69.74 M3       0/HR         0                0

                    AREA M2        RSI VALUE M2-DEGC/W
CEILING             31.54          3.33
            TOTAL   31.54          3.33         0.00             26.59
MAIN WALLS          35.74          2.42
            TOTAL   35.74          2.42         14.77            44.28
DOORS               .00            .00
            TOTAL   .00            .00          .00              .00
BASEMENT AB.GD      .00            .00
            TOTAL   .00            .00          .00              .00
BASEMENT BRKPT      .00            .00
            TOTAL   .00            .00          .00              .00
BASE TO FLOOR       .00            .00
            TOTAL   .00            .00          .00              .00
FLOOR PERIMETER     .00            .00
            TOTAL   .00            .00          .00              .00
FLOOR CENTRE        .00            .00
            TOTAL   .00            .00          .00              .00
SOUTH WINDOWS       2.79           .38
            TOTAL   2.79           .38          7.38             21.55
NORTH WINDOWS       .96            .38
            TOTAL   .96            .38          2.54             7.44
EAST WINDOWS        .00            .00
            TOTAL   .00            .00          .00              .00
WEST WINDOWS        .00            .00
            TOTAL   .00            .00          .00              .00
```



```
HOTCAN                                                        PAGE 2

S-EAST WINDOWS      .00            .00
            TOTAL   .00            .00          .00              .00
S-WEST WINDOWS      .00            .00
            TOTAL   .00            .00          .00              .00

ADDRESS    : 21-53 QUEEN ST OTTAWA

DESIGN HEAT LOSS AT -25C = 1.54 KW
DEGREE DAYS FOR OTT-1971 IS 4751
TEMPERATURES (DEG C) MAIN FLOOR = 20   BASEMENT = 20
SENSIBLE HEAT GAIN FROM PEOPLE (KWH/D) = 0
DAILY BASE ELECTRIC CONSUMPTION (KWH/D) = 0
DAILY HOT WATER ENERGY CONSUMPTION (KWH/D) = 0
MASS LEVEL CHOSEN IS (A)
BASEMENT INSULATED PRIMARILY FROM THE INSIDE
WINDOW SHADING COEFFICIENTS: SOUTH = .83   NORTH = .83
                             EAST  = 0     WEST  = 0
                             S-EAST = 0    S-WEST = 0
SOUTH OVERHANG GEOMETRY; AVERAGE WINDOW HEIGHT = 1 M
                         AVERAGE OVERHANG WIDTH = 0 M
                         AVERAGE HEIGHT ABOVE WINDOW = 0 M
NATURAL INFILTRATION RATE (AC/HR) = 0
 FORCED VENTILATION RATE (AC/HR) = 0

                *** MONTHLY SUMMARY OF ENERGY CONSUMPTION ***

MONTH   THERMAL LOAD KWH/D   MONTHLY SOLAR FRAC   AUX HEAT REQ KWH/D   TOT CONS KWH/D
JAN     26.78                .29                  21.47                21.47
FEB     22.61                .22                  17.62                17.62
MAR     19.49                .34                  12.96                12.96
APR     13.47                .39                  9.23                 8.23
MAY     5.61                 .71                  1.65                 1.65
JUN     1.28                 1.00                 .00                  .00
JUL     .00                  1.00                 .00                  .00
AUG     1.69                 1.00                 .00                  .00
SEP     2.97                 .88                  .25                  .25
OCT     7.78                 .42                  4.45                 4.45
NOV     16.68                .18                  13.68                13.68
DEC     21.73                .19                  17.81                17.81

            *** YEARLY ENERGY CONSUMPTION COMPARISONS ***

12 MONTH HEATING SEASON IN EFFECT
ANNUAL SOLAR HEATING CONTRIBUTION = 38 %

ESTIMATED ANNUAL SPACE HEATING 19 GJ, OR          2,966 KWHRS
SEER PROGRAM ENERGY BUDGET FOR SPACE HEATING =    1,193 KWHRS

PREDICTED ANNUAL AUXILIARY ENERGY CONSUMPTION =       0 KWHRS
SEER PROGRAM AUXILIARY ENERGY CONSUMPTION =      10,680 KWHRS

TOTAL ANNUAL ENERGY CONSUMPTION =                 2,966 KWHRS
TOTAL ANNUAL SEER PROGRAM ENERGY BUDGET =         11,793 KWHRS
```

FIGURE 3.6.2 HOTCAN - SAMPLE OUTPUT

```
HOTCAN                                                        PAGE 3

                *** ANNUAL PREDICTED FUEL COSTS ***

FUEL COSTS ARE FOR ONTARIO              AS OF 84/04/0x

ENERGY SOURCE   COST PER UNIT   SPACE HEATING          HOT WATER              LIGHTS AND APPLIANCES
ELECTRICITY     5.5C/KWH       $ 163.17/YR            $ 0/YR                 $ 0/YR
                               EFF.= 100%             EFF.= 100%             EFF.= 100%

**********  **********

    This estimate of energy demand may not reflect actual
energy requirements of a house due to variations in
weather, performance of equipment, and the lifestyle
of the occupants.

**********
```

ACCURACY:

HOTCAN produced results for the NRC Lightweight and Alberta Energy Conservation test cells that were consistent with the corresponding estimated annual energy consumption (see Figure 3.6.3). Results obtained for the NRC Heavyweight and Alberta Passive Solar Test Cell were not consistent with the estimated annual energy consumption. Examination of the monthly values showed problems with the estimation of energy consumption in the spring and fall months for all test cells.

HOTCAN is not capable of modelling attached sunspaces and Trombe walls.

PROGRAM ACCURACY

HOTCAN

■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
● -NRC TOMBE WALL TEST CELL
□ -NRC SUNSPACE TEST CELL
△ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

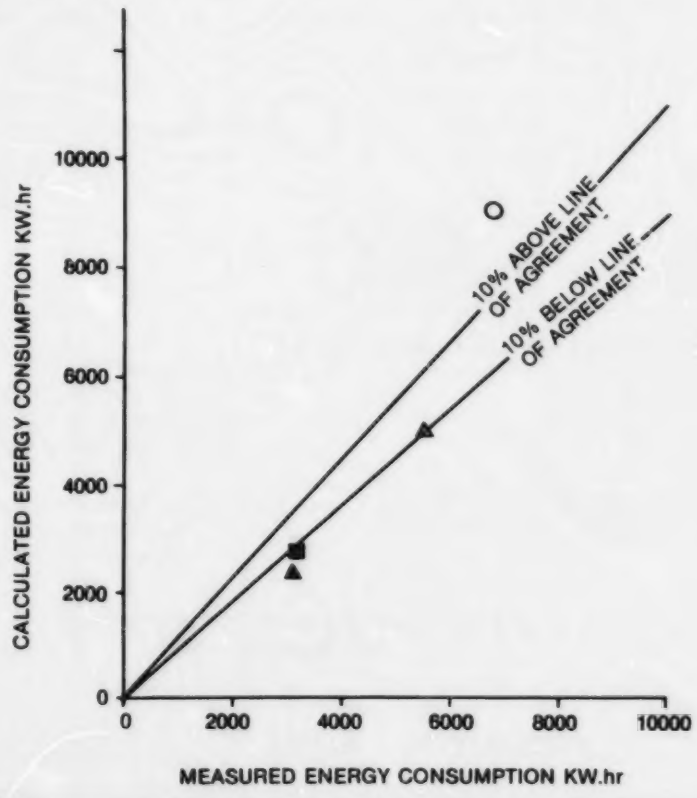


FIGURE 3.6.3 HOTCAN - PROGRAM ACCURACY

EASE OF USE:

An experienced user will find HOTCAN simple and fast to use. However, some input errors are awkward to correct as the user is not completely free to "back track" and "skip forward" through the input procedure.

The meaning of each program option on the main menu may not be clear, to the new user. The new user may also find it difficult to get back to the main menu.

The input format is inflexible; one response per line and uppercase only. The program will give a "beep" and "WHAT?" response to data entered in the wrong format. There appears to be little checking for other types of errors. Accepted data is echoed at various points of the input procedure (an error is not echoed) so the user can verify the data. This, however, slows down the input process and can be annoying.

Documentation was not available for the evaluators. The supporting agency felt the program can be used without documentation. However, consistency of results was only fair between each of the evaluators, which could be partially attributed to the simplified input being open to misinterpretation.

The graphical output was appreciated, especially the capability of representing two simulations on one graph. Sections of the echo of input parameters are difficult to follow, a few more headings and blank lines would help. The meaning of some of the output headings is not immediately apparent.

CONCLUSIONS & GENERAL COMMENTS:

HOTCAN is limited to fairly simple residential designs. The program can only model direct gain passive solar designs (with overhangs and insulated shutters). In contrast the program has a fairly detailed basement model. The program would be more useful to designers rather than researchers.

The program is easy to learn, has a low purchase cost ($55) and is inexpensive to use (simple input requirements and a minimum of external calculation.) The graphical output provides the user with a quick way of analysing the results.

HOTCAN does require some documentation (not available at the time of the evaluation) to ensure proper interpretation of input parameters.

3.7 SERI-RES

PROGRAM:

SERI-RES (Version 1.0)
Program Authors:

Larry Palmiter & Terry Wheeling,
Ecotope Group,
2328 East Madison,
Seattle, Washington 98112

Supporting Agency:

The Solar Energy Research Institute,
1617 Cole Boulevard,
Golden, Colorado 80401,
(303) 231-1000
CONTACT: Ronald Judkoff

PURPOSE:

SERI-RES (Solar Energy Research Institute - Residential Energy Simulator) was developed to model the thermal performance of residential and small commercial buildings, particularly those designs with passive solar features.

METHOD:

SERI-RES translates the user's description of the building into a network of mathematical equations. Each set of equations are repeatedly solved at one hour (or less) time intervals. The equations are solved using a combination of forward finite differences, Jacobian iteration and constrained optimization.

HARDWARE & RELATED SOFTWARE:

SERI-RES can be installed on most mini-computers and mainframes that have an extended FORTRAN IV or a standard FORTRAN 77 compiler. (Random file access is the primary extension required in FORTRAN IV.)

The documentation warns that modification ot the program is inevitable for installation on a specific system. The documentation recommends that a programmer, experienced with the computer's operating system and FORTRAN, will be required.

The program has been written in well-defined and structured modules. There are very good comments that explains the variables and procedures. There is also a fairly extensive section in the documentation to assist in any required modifications.

Hourly weather tapes of Canadian locations, in the required format, are not available. A programmer would be helpful in reformatting Canadian weather tapes as available from the Atmospheric Environment Service.

PROGRAM OPERATION:

There are two main modules, an EDITOR and calculation (LOADS) module.

Using the various commands made available through the EDITOR module the user can create, modify and save input files. The EDITOR is also used to create a compiled version of the input file, during which time the input data is checked for errors. The LOADS module uses this intermediate file to perform the calculation.

A typical modelling session is shown in Figure 3.7.1.

7 **DATA COLLECTION** EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATION" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS.

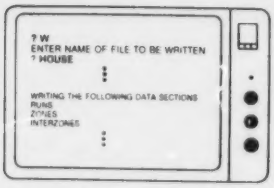
12 **INPUT DATA PREPARATION** FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT THE DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM.

LOAD SERI-RES EDIT PROGRAM (SEE NOTE 1)

START HERE FOR PARAMETRIC SIMULATIONS

CREATE INPUT FILE
- USE THE APPROPRIATE COMMANDS
- E.G. " M" IS AN ABBREVIATION FOR MAKE A FILE.
  "A" IS AN ABBREVIATION FOR ADD A DATA ENTRY STRING

EDIT INPUT FILE
- USE THE APPROPRIATE COMMANDS
- E.G. R - READ IN FILE
  E - EDIT DATA ENTRY STRING



14

SAVE INPUT FILE

14:03

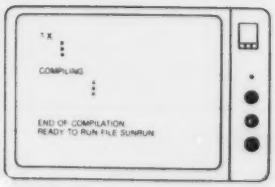
EXECUTE EDIT PROGRAM

PROGRAM CHECKS FOR ERRORS

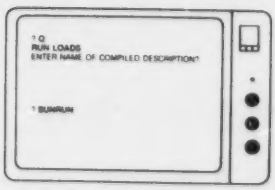
14:06

ERRORS → **YES**

NO
- PROGRAM CREATES INTERMEDIATE COMPILED INPUT FILE TO BE USED BY LOADS.

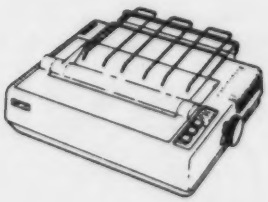


EXIT EDIT PROGRAM
- Q IS ABBREVIATION FOR QUIT



LOAD SERI-RES LOADS PROGRAM
- ENTER INTERMEDIATE FILENAME
- LOADS PERFORMS AN HOURLY SIMULATION AND WRITES THE OUTPUT DATA TO A FILE

14:51



PRINT OUTPUT FILE
- THE COMMAND WOULD BE SYSTEM DEPENDENT

14:52

NOTES:

TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN. SEE APPENDIX D FOR DETAILS. THE FULL RANGE OF FEATURES AND DISPLAYED INFORMATION ARE OMITTED FOR CLARITY.

NOTE 1 - ASSUMES THAT SERI-RES (EDIT AND LOADS PROGRAM) HAS BEEN INSTALLED ON THE SYSTEM, AND THE USER HAS ALREADY LOGGED ON.

FIGURE 3.7.1 SERI-RES - TYPICAL MODELLING SESSION

MAJOR PROGRAM FEATURES:

SERI-RES is capable of modelling the thermal performance of multizone (up to 10 zones) buildings. The model includes interzone heat transfer, which can be defined;

i) as a rate of heat exchange per temperature temperature difference (i.e. in BTU/hr. deg. F or W/deg. C);
ii) as fans that come on at a specified temperature difference;
iii) and as a fraction (may be scheduled) of the solar gain to be passed directly into another zone.

The user can specify an exterior or interior surface of any dimension, orientation, tilt, and define the thermal characteristics (conductivity, density, specific heat and thickness) of the construction materials for each wall-layer. Optionally, a simple R-value may be defined for a wall layer. The manual recommends the detailed description be used for the interior or the most thermally massive layers and treat the rest of the layers as pure resistance. Each surface may be linked to any zone, the ambient or ground. SERI-RES does not perform a rigorous heat loss to ground analysis and instead relies on simple one-dimensional heat loss to user scheduled ground temperatures.

SERI-RES is capable of modelling; attached sunspaces, rock bin thermal storage (with passive or fan induced heat transfer), vented Trombe walls, phase change materials and overhang and sidefins (assumed to be infinite in length).

The program models infiltration using a user-scheduled air-change rate or by letting the program default to a wind speed and temperature dependent model. The default method requires the user to enter a multiplier factor: to adjust the absolute values of the calculated default rates to values appropriate to the building being modelled. The documentation does not give advice on what may be an appropriate factor for a given application. Ventilation must be modelled as infiltration, which creates some limitations since it is not possible to have, for instance, a user scheduled ventilation rate plus wind and stack infiltration.

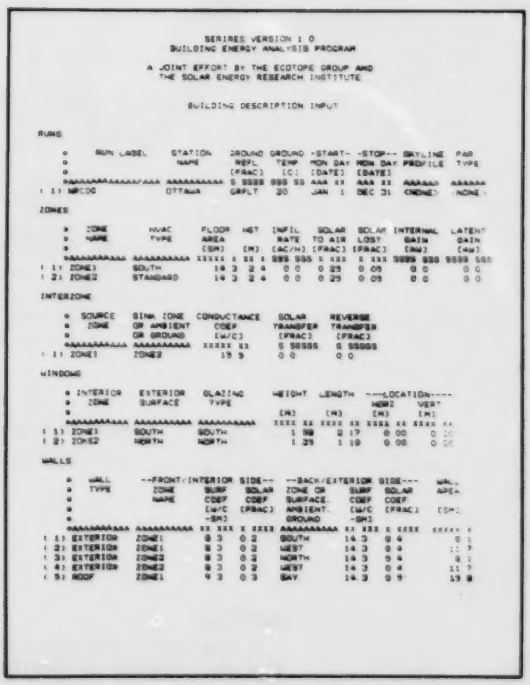
Windows are defined by specifying their U-value: glazing material properties (extinction coefficient, index of refraction and thickness); and number of glazing layers. A "shading coefficient" is also required for any additional window system component such as blinds or drapes.

SERI-RES does not peform a system simulation, i.e. equipment performances are not modelled. The user may specify up to 10 "HVAC TYPES" by scheduling a heating, excess heat venting and cooling setpoints, along with the corresponding heating, venting and cooling capacities. The program calculates the energy "addition" or "extraction" required to maintain the setpoint temperature.

The user may choose to output hourly, daily, monthly and/or annual data on individual building components (i.e. walls, windows, rock bins etc.), zones and/or for the total building. A wide selection of "OUTPUT DATA SECTIONS" are available. For example, the following may be output:

- for a particular component; the incident, transmitted and absorbed solar radiation; conduction; and the surface temperature;
- the heat delivered by a fan, fan operating hours, and inlet and outlet temperatures;
- zone and building heating/cooling peak loads, energy consumptions, and average tempeatures.

The user must be selective and choose only the output that is needed or else many pages of output will result. There is no advice in the documentation on which "OUTPUT DATA SECTIONS" are most useful for a given application. (i.e. to get monthly or annual energy consumption results). The meaning of the output headers can be confusing (especially to a new user) and requires frequent reference to the manual. (See Figure 3.7.2 for sample output.)



SERIRES VERSION 1.0
BUILDING ENERGY ANALYSIS PROGRAM

A JOINT EFFORT BY THE ECOTOPE GROUP AND
THE SOLAR ENERGY RESEARCH INSTITUTE

BUILDING DESCRIPTION INPUT

RUNS

	RUN LABEL	STATION NAME	GROUND REFL (FRAC)	GROUND TEMP (C)	-START- MON DAY (DATE)	-STOP- MON DAY (DATE)	SKYLINE PROFILE	PAR TYPE
(1)	NRCDC	OTTAWA	GRFLT	20	JAN 1	DEC 31	(NONE)	(NONE)

ZONES

	ZONE NAME	HVAC TYPE	FLOOR AREA (SM)	HGT (M)	INFIL RATE (AC/H)	SOLAR TO AIR (FRAC)	SOLAR LOST (FRAC)	SOLAR (W)	INTERNAL GAIN (W)	LATENT GAIN (W)
(1)	ZONE1	SOUTH	14.3	2.4	0.0	0.25	0.05	0.0	0.0	0.0
(2)	ZONE2	STANDARD	14.3	2.4	0.0	0.25	0.05	0.0	0.0	0.0

INTERZONE

	SOURCE ZONE OR AMBIENT OR GROUND	SINK ZONE OR AMBIENT	CONDUCTANCE (W/C)	SOLAR TRANSFER (FRAC)	REVERSE TRANSFER (FRAC)
(1)	ZONE1	ZONE2	19.9	0.0	0.0

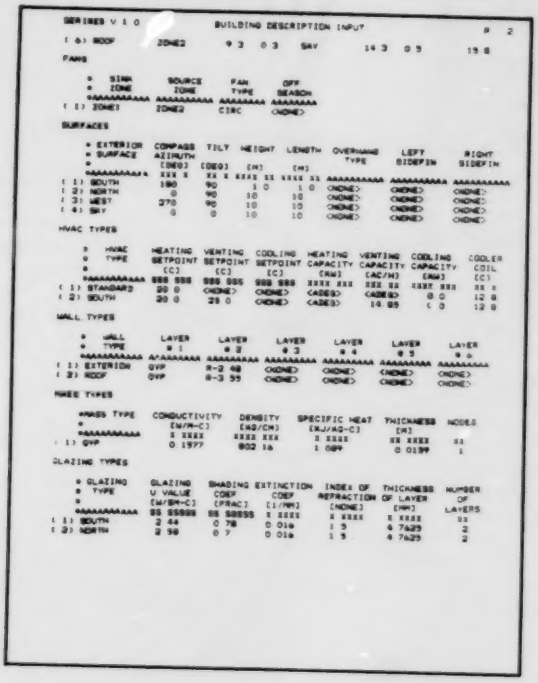
WINDOWS

	INTERIOR ZONE	EXTERIOR SURFACE	GLAZING TYPE	HEIGHT (M)	LENGTH (M)	---LOCATION--- HORZ (M)	VERT (M)
(1)	ZONE1	SOUTH	SOUTH	1.98	2.17	0.00	0.20
(2)	ZONE2	NORTH	NORTH	1.25	1.10	0.00	0.20

WALLS

	WALL TYPE	--FRONT/INTERIOR SIDE-- ZONE NAME	SURF COEF (W/C)	SOLAR COEF (FRAC)	--BACK/EXTERIOR SIDE--- ZONE OR SURFACE AMBIENT GROUND	SURF COEF (W/C)	SOLAR COEF (FRAC)	WALL AREA (SM)
			(SM)			(SM)		
(1)	EXTERIOR	ZONE1	8.3	0.2	SOUTH	34.5	0.4	8.1
(2)	EXTERIOR	ZONE1	8.3	0.2	WEST	34.3	0.4	11.7
(3)	EXTERIOR	ZONE2	8.3	0.2	NORTH	34.5	0.4	8.1
(4)	EXTERIOR	ZONE2	8.3	0.2	WEST	34.3	0.4	11.7
(5)	ROOF	ZONE1	9.3	0.3	SKY	34.3	0.9	19.8

FIGURE 3.7.2 SERI-RES - SAMPLE OUTPUT



SERIRES V 1 0 BUILDING DESCRIPTION INPUT P 2

(6) ROOF ZONE2 9 3 0 3 SAV 14 3 0 5 15 6

FANS

	SIM ZONE	SOURCE ZONE	FAN TYPE	OFF SEASON
(1) ZONE1		ZONE2	CIRC	<NONE>

SURFACES

	EXTERIOR SURFACE	COMPASS AZIMUTH (DEG)	TILT (DEG)	HEIGHT (M)	LENGTH (M)	OVERHANG TYPE	LEFT SIDEFIN	RIGHT SIDEFIN
(1)	SOUTH	180	90	3 0	3 0	<NONE>	<NONE>	<NONE>
(2)	NORTH	0	90	3 0	3 0	<NONE>	<NONE>	<NONE>
(3)	WEST	270	90	3 0	3 0	<NONE>	<NONE>	<NONE>
(4)	SKY	0	0	3 0	3 0	<NONE>	<NONE>	<NONE>

HVAC TYPES

	HVAC TYPE	HEATING SETPOINT (C)	VENTING SETPOINT (C)	COOLING SETPOINT (C)	HEATING CAPACITY (KW)	VENTING CAPACITY (AC/H)	COOLING CAPACITY (KW)	COOLER COIL (C)
(1)	STANDARD	20 0	<NONE>	<NONE>	<ADEQ>	<ADEQ>	0 0	12 8
(2)	SOUTH	20 0	25 0	<NONE>	<ADEQ>	10 85	0 0	12 8

WALL TYPES

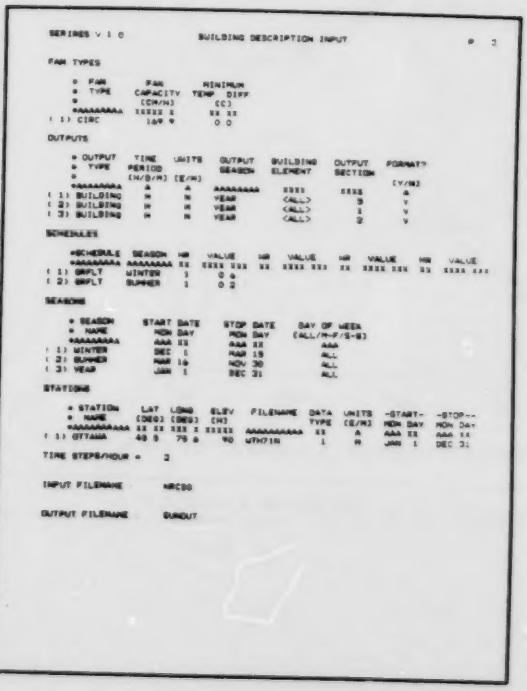
	WALL TYPE	LAYER # 1	LAYER # 2	LAYER # 3	LAYER # 4	LAYER # 5	LAYER # 6
(1)	EXTERIOR	GYP	R-2 48	<NONE>	<NONE>	<NONE>	<NONE>
(2)	ROOF	GYP	R-3 55	<NONE>	<NONE>	<NONE>	<NONE>

MASS TYPES

	MASS TYPE	CONDUCTIVITY (W/M-C)	DENSITY (KG/CM)	SPECIFIC HEAT (KJ/KG-C)	THICKNESS (M)	NODES
(1)	GYP	0 1977	802 16	1 089	0 0199	1

GLAZING TYPES

	GLAZING TYPE	GLAZING U VALUE (W/SM-C)	SHADING COEF (FRAC)	EXTINCTION COEF (1/MM)	INDEX OF REFRACTION (NONE)	THICKNESS OF LAYER (MM)	NUMBER OF LAYERS
(1)	SOUTH	2 44	0 78	0 016	1 5	4 7629	2
(2)	NORTH	2 56	0 7	0 016	1 5	4 7629	2



SERIRES V 1 0 BUILDING DESCRIPTION INPUT P 3

FAN TYPES

	FAN TYPE	FAN CAPACITY (CM/H)	MINIMUM TEMP DIFF (C)
(1)	CIRC	169 9	0 0

OUTPUTS

	OUTPUT TYPE	TIME PERIOD (H/D/M)	UNITS (E/M)	OUTPUT SEASON	BUILDING ELEMENT	OUTPUT SECTION	FORMAT? (Y/N)
(1)	BUILDING	H	M	YEAR	<ALL>	5	Y
(2)	BUILDING	H	M	YEAR	<ALL>	1	Y
(3)	BUILDING	H	M	YEAR	<ALL>	2	Y

SCHEDULES

	SCHEDULE	SEASON	HR	VALUE	HR	VALUE	HR	VALUE	HR	VALUE
(1)	GRPLT	WINTER	1	0 6						
(2)	GRPLT	SUMMER	1	0 2						

SEASONS

	SEASON NAME	START DATE MON	START DATE DAY	STOP DATE MON	STOP DATE DAY	DAY OF WEEK (ALL/M-F/S-S)
(1)	WINTER	DEC	1	MAR	15	ALL
(2)	SUMMER	MAR	16	NOV	30	ALL
(3)	YEAR	JAN	1	DEC	31	ALL

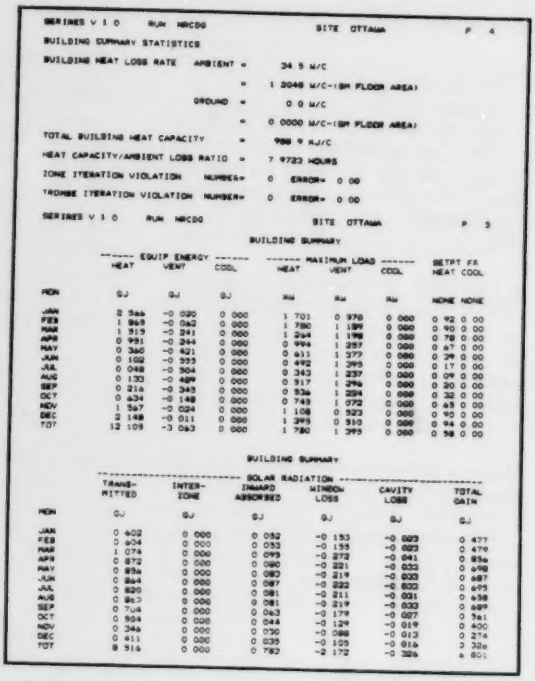
STATIONS

	STATION NAME	LAT (DEG)	LONG (DEG)	ELEV (M)	FILENAME	DATA TYPE	UNITS (E/M)	-START- MON	-START- DAY	-STOP- MON	-STOP- DAY
(1)	OTTAWA	45 3	75 6	90	WYH?IN	1	M	JAN	1	DEC	31

TIME STEPS/HOUR = 2

INPUT FILENAME HRCSO

OUTPUT FILENAME DUMOUT



SERIRES V 1 0 RUN HRCSO SITE OTTAWA P 4

BUILDING SUMMARY STATISTICS

BUILDING HEAT LOSS RATE AMBIENT = 34 9 W/C
= 1 3048 W/C-(SM FLOOR AREA)
GROUND = 0 0 W/C
= 0 0000 W/C-(SM FLOOR AREA)

TOTAL BUILDING HEAT CAPACITY = 988 9 MJ/C

HEAT CAPACITY/AMBIENT LOSS RATIO = 7 9723 HOURS

ZONE ITERATION VIOLATION NUMBER= 0 ERROR= 0 00

TROMBE ITERATION VIOLATION NUMBER= 0 ERROR= 0 00

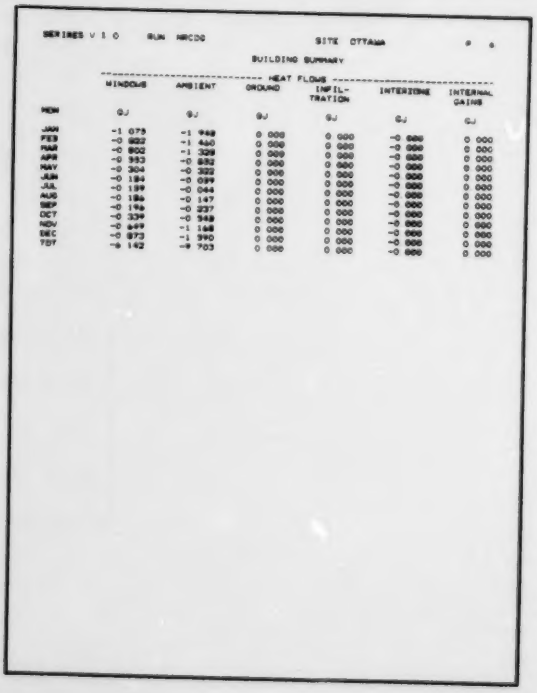
SERIRES V 1 0 RUN HRCSO SITE OTTAWA P 5

BUILDING SUMMARY

	EQUIP ENERGY HEAT	EQUIP ENERGY VENT	EQUIP ENERGY COOL	MAXIMUM LOAD HEAT	MAXIMUM LOAD VENT	MAXIMUM LOAD COOL	SETPT FR HEAT	SETPT FR COOL
	GJ	GJ	GJ	KW	KW	KW	NONE	NONE
JAN	2 344	-0 020	0 000	1 701	0 979	0 000	0 92	0 00
FEB	1 868	-0 062	0 000	1 780	1 197	0 000	0 90	0 00
MAR	1 519	-0 241	0 000	1 244	1 198	0 000	0 78	0 00
APR	0 981	-0 244	0 000	0 994	1 257	0 000	0 67	0 00
MAY	0 346	-0 421	0 000	0 611	1 277	0 000	0 39	0 00
JUN	0 102	-0 333	0 000	0 492	1 295	0 000	0 17	0 00
JUL	0 048	-0 304	0 000	0 343	1 237	0 000	0 09	0 00
AUG	0 133	-0 489	0 000	0 343	1 237	0 000	0 09	0 00
SEP	0 216	-0 343	0 000	0 517	1 296	0 000	0 20	0 00
OCT	0 634	-0 148	0 000	0 936	1 294	0 000	0 32	0 00
NOV	1 567	-0 148	0 000	0 748	1 272	0 000	0 65	0 00
DEC	2 148	-0 011	0 000	1 108	0 523	0 000	0 90	0 00
TOT	12 109	-3 063	0 000	1 780	1 295	0 000	0 58	0 00

BUILDING SUMMARY

	TRANSMITTED	INTERZONE	SOLAR RADIATION INWARD ABSORBED	SOLAR RADIATION WINDOW LOSS	SOLAR RADIATION CAVITY LOSS	TOTAL GAIN
	GJ	GJ	GJ	GJ	GJ	GJ
JAN	0 602	0 000	0 052	-0 153	-0 023	0 477
FEB	0 604	0 000	0 053	-0 155	-0 023	0 479
MAR	1 074	0 000	0 093	-0 272	-0 041	0 854
APR	0 872	0 000	0 080	-0 221	-0 033	0 698
MAY	0 836	0 000	0 083	-0 219	-0 033	0 667
JUN	0 864	0 000	0 087	-0 222	-0 033	0 697
JUL	0 820	0 000	0 081	-0 211	-0 031	0 659
AUG	0 863	0 000	0 081	-0 219	-0 033	0 697
SEP	0 748	0 000	0 063	-0 179	-0 027	0 561
OCT	0 594	0 000	0 044	-0 129	-0 019	0 400
NOV	0 346	0 000	0 030	-0 088	-0 013	0 274
DEC	0 411	0 000	0 035	-0 105	-0 016	0 329
TOT	8 516	0 000	0 782	-2 172	-0 326	6 801



SERIRES V 1 0 RUN HRCSO SITE OTTAWA P 6

BUILDING SUMMARY

	HEAT FLOWS WINDOWS	HEAT FLOWS AMBIENT	HEAT FLOWS GROUND	HEAT FLOWS INFILTRATION	HEAT FLOWS INTERZONE	HEAT FLOWS INTERNAL GAINS
	GJ	GJ	GJ	GJ	GJ	GJ
JAN	-1 073	-1 948	0 000	0 000	-0 000	0 000
FEB	-0 802	-1 460	0 000	0 000	-0 000	0 000
MAR	-0 802	-1 328	0 000	0 000	-0 000	0 000
APR	-0 353	-0 852	0 000	0 000	-0 000	0 000
MAY	-0 304	-0 322	0 000	0 000	-0 000	0 000
JUN	-0 134	-0 089	0 000	0 000	-0 000	0 000
JUL	-0 139	-0 044	0 000	0 000	-0 000	0 000
AUG	-0 184	-0 147	0 000	0 000	-0 000	0 000
SEP	-0 196	-0 227	0 000	0 000	-0 000	0 000
OCT	-0 339	-0 548	0 000	0 000	-0 000	0 000
NOV	-0 649	-1 168	0 000	0 000	-0 000	0 000
DEC	-0 873	-1 990	0 000	0 000	-0 000	0 000
TOT	-6 142	-9 703	0 000	0 000	-0 000	0 000

FIGURE 3.7.2 (continued) SERI-RES - SAMPLE OUTPUT

ACCURACY:

Figure 3.7.3 shows goodagreement between the energy consumption, calculated by SERI-RES, and the measured values. The only exception is for the Alberta Test Hut - Passive Solar Module where it appeared that the program underestimated the solar contribution (as was the case with the other programs tested).

However, an hour-by-hour comparison between measured and calculated temperatures showed unexplainable discrepancies in each zone for the NRC Sunspace and two Alberta Test Cells. (The supporting agency could not find any problem with the input data.)

When a schedule to model a night setback strategy was introduced into the Lightweight test cell simulation, the results showed that one of the zones was simulated as an unconditioned zone. A fix suggested by the supporting agency did not solve the problem.

PROGRAM ACCURACY

SERI-RES

■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
● -NRC TOMBE WALL TEST CELL
□ -NRC SUNSPACE TEST CELL
△ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

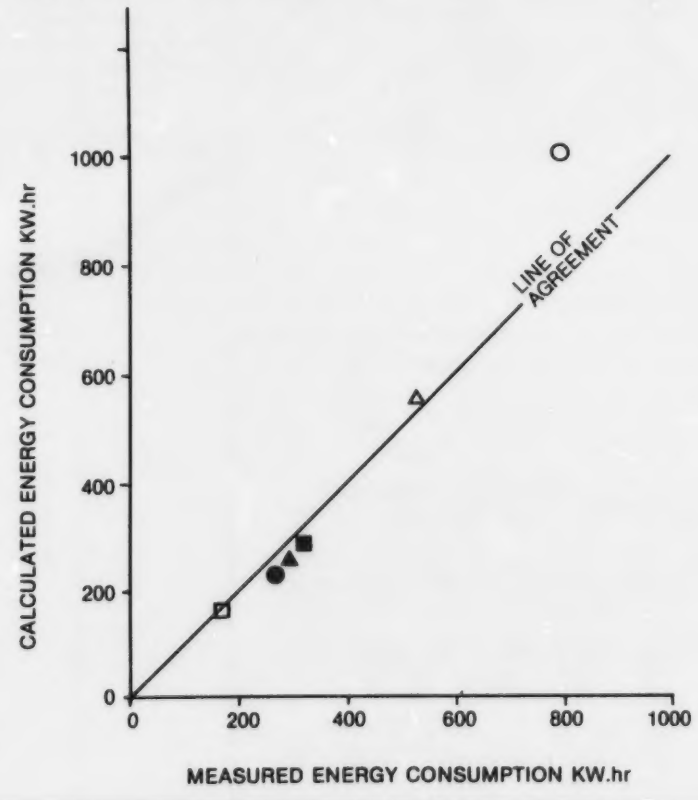


FIGURE 3.7.3 SERI-RES - PROGRAM ACCURACY

EASE OF USE:

As a result of being such a detailed and flexible tool, SERI-RES is difficult to learn. This problem could be partially alleviated with a better organized manual. The manual provides a great deal of useful information to the user, but it is often difficult to find. There is no index and the table of contents is of limited use. It would bebetter if the examples and reference data were placed in appendices as they are currently scattered throughout the manual and tend to break up its continuity.

File manipulation and edit commands allow the user to easily create, edit and save input files. Commands have a l or 2 character abbreviation. The new user will find there are too many comands and "switches" to commit to memory. (Switches allow for multiple commands on one line.) The experienced user will find that the range of commands and switches will speed up the use of the program. Data edit can sometimes be awkward, for example E ,,,,,,11 would replace the number in the seventh column with an eleven; the commas are confusing. When the EDITOR module (see PROGRAM OPERATION) creates the intermediate file, error checking is performed, thus if an error is found the user must return to the edit mode (slightly awkward) to correct the input. Errors are usually displayed with a meaningful message, however, error checking is limited and many inconsistencies in the input data are not identified.

Input forms, provided in the documentation, are essential to ensure proper interpretation of prompts and to minimize input errors. The documentation indicated that SERI-RES has a help facility, but none was available in the version that was tested.

CONCLUSIONS & GENERAL COMMENTS:

SERI-RES is potentially a very good research program, it has the capability, flexibility and apparent accuracy to model many types of designs (it was the most powerful of the programs tested), but as a result it can be difficult to learn. A better organized manual would help.

Entering the detailed input requirement is time-consuming, but this means the user does not have to make many external calculations (which are also time-consuming). A detailed input also provides for a potentially more accurate model.

The cost of using the program (especially if the user is required to pay full rates charged by a computer bureau) can be a deterrent to its use. The computation cost for a full year complex house simulation can be around $l00 (assuming full rates). The purchase cost ($l,l00 U.S.) was higher than the other programs.

3.8 SUNPAS

PROGRAM:

SUNPAS/SUNOP (Version 4.0)

Program Authors:

Solarsoft Inc.
1406 Burlingame Ave., Suite 31,
Burlingame, California, 94010
(415) 342-3338

PURPOSE:

The "SUNPAS/SUNOP Package" allows the user to estimate the auxiliary energy requirements (SUNPAS) and the economics (SUNOP) of passive solar designs in single zone buildings (i.e. residential and small commercial buildings).

NOTE: This evaluation primarily addresses the SUNPAS part of the program package.

METHOD:

SUNPAS is based on the Solar Load Ratio (SLR) method, a hand method developed at the Los Alamos Scientific Laboratory (Reference 2).

The solar load ratio is the ratio of solar gain to building heat load. The SLR is correlated with the monthly solar saving fraction (SSF) which is the energy savings due to a passive solar design feature relative to the energy requirements of a reference building that has an "energy-neutral" wall in place of the passive feature. The SLR correlations were developed for many variations of several passive solar features (e.g. Direct Gain, Trombe Walls, Waterwalls, Sunspaces), using computer simulations validated against data obtained from the Los Almos passive solar test cells. The SLR Method in the program has been "enhanced", such that a greater range of buildings and design features may be modelled. The program also incorporates a variable base degree day method (developed at the Lawrence Berkeley Laboatory) which is used in the calculation of auxiliary heating and cooling.

NOTE: The evaluators have been informed by the program authors that the methodologies used in SUNPAS are approved by ASHRAE and the California Energy Commission for predicting residential energy use.

HARDWARE & RELATED SOFTWARE:

SUNPAS runs on an IBM-PC (128 K) and "close" IBM-PC compatibilities; Apple II (64 K), Apple III (256 K), and Apple Lisa (with 7/7 Office systems). Early in 1985 the program will also run on an Apple MacIntosh. This evaluation is based on the IBM-PC version.

The program requires two disk drives or a disk drive and a hard-disk. A printer is not necessary, but highly recommended. If the graphic output option is desired, then an IBM colour adapter card, a colour monitor, and an IBM or Epson dot matrix printer is required.

PROGRAM OPERATION:

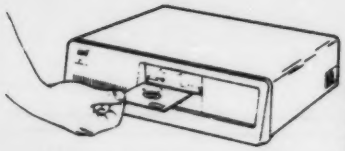
SUNPAS is menu driven, i.e. lists of possible user responses are displayed at several points in the program. This allows the analyst to proceed to various sections in the program or to perform various tasks such as, save, retrieve or enter data.

Building description and weather data is entered via a "full screen data entry" facility (see the Glossary - Appendix A).

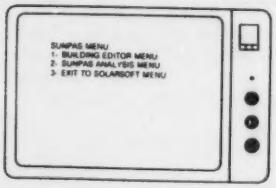
Figure 3.8.1 represents a typical modelling session.

7 **DATA COLLECTION** EXTRACT INFORMATION FROM DRAWINGS AND CARRY OUT "TRIVIAL CALCULATION" SUCH AS CALCULATING WALL AREAS FROM BUILDING DIMENSIONS.

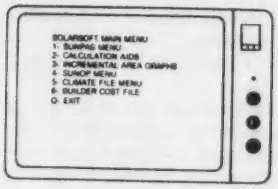
7:30 **INPUT DATA PREPARATION** FILL OUT INPUT DATA SHEETS. CARRY OUT "NON-TRIVIAL CALCULATIONS" SUCH THAT THE DATA IS IN A FORM ACCEPTABLE TO THE PROGRAM.



INSERT MASTER PROGRAM AND WORKING DISKS IN DISK DRIVES. TURN ON MACHINE. AFTER PROGRAM INITIALIZATION REMOVE MASTER DISKS AND REPLACE WITH BACK UP DISCS.



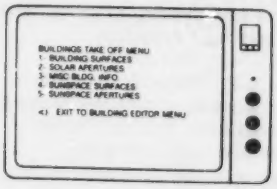
SELECT SUNPAS MENU (ITEM 1)



SELECT BUILDING EDITOR MENU (ITEM 1)
- USER MAY "LOAD" (& "SAVE") BUILDING, SUNSPACE, AND CLIMATE FILES FROM WORKING DISK.
- SELECT THE "BUILDING TAKE OFF MENU"

7:35

USING THE "BUILDING TAKE OFF MENU" BUILDING DESCRIPTION CAN BE ENTERED OR EXISTING FILES EDITED.

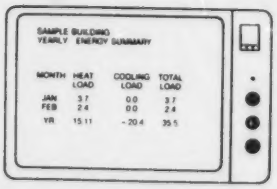


MISCELLANEOUS BUILDING INFORMATION
TOTAL FLOOR AREA (SQ FT.) 1344.00
CEILING AREA (SQ FT.) 1344.00
CEILING ABSORPTANCE 0.50
WALL ABSORPTANCE 0.50

— USER SELECTS THE APPROPRIATE MENU ITEMS AND USES THE "CURSOR" AND "RETURN" KEYS TO ENTER DATA.

8:10

EXIT TO THE "SUNPAS MENU" AND SELECT THE "SUNPAS ANALYSIS MENU" (ITEM 2)
IE "RUN" PROGRAM



8:11

OUTPUT DATA
SELECT APPROPRIATE ITEMS FROM "SUNPAS ANALYSIS MENU" & "SUNPAS GRAPH MENU"

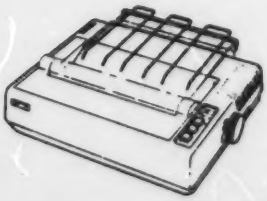
8:15

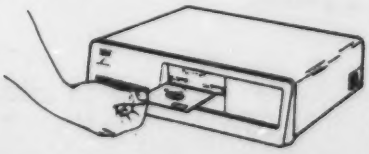
EXIT TO SUNPAS MENU ADDITIONAL RUNS REQUIRED?

YES

NO

EXIT PROGRAM & REMOVE DISKS





NOTES:
TIMES GIVEN ARE FOR A COMPLEX HOUSE DESIGN. SEE APPENDIX D FOR DETAILS. THE FULL RANGE OF FEATURES AND INFORMATION ARE OMITTED FOR CLARITY.

FIGURE 3.8.1 SUNPAS - TYPICAL MODELLING SESSION

MAJOR PROGRAM FEATURES:

The analyst may choose from the following passive solar features (i.e. SLR correlations have been developed for each design variation):

i) 15 variations of waterwalls
ii) 21 vented Trombe walls
iii) 21 unvented Trombe walls.

(The finite number of variations available in items i), ii) and iii) include alternative thermal characteristics; wall thicknesses; number of glazings; night insulation; and normal versus selective surfaces.)

iv) 28 sunspace sytems. Variations include; attached or semi-enclosed; glazing tilt; insulated or uninsulated common wall; opaque or glazed end walls; and night insulation.

v) 9 direct gain systems. Variation include; number of glazings; mass to glass area ratio; level of thermal storage; and night insulation.

In addition to the SLR direct gain systems there are "SL" direct gain systems, which permit both cooling and heating loads to be calculated. The analyst has greater flexibility to describe the building model as SL types allow any mass-to-glass ratios and any thermal capacities to be specified.

SUNPAS allows the user to specify up to a total of 40 surfaces (walls and roofs) and subsurfaces (windows, doors, sunspaces and trombe walls) in any orientation and tilt.

Shading may be described as an overhang or as "Site Shading Patterns". Each solar aperture (windows, sunspaces, etc.) is assigned to a shading pattern (up to five types may be defined) which consists of 12 monthly values of the percent the aperture is unshaded.

SUNPAS does not perform a system simulation, but the programs does allow the user to enter day (8 a.m. - 8 p.m.) and night (8 p.m. - 8 a.m.) heating and cooling setpoints. (The night setpoint is only functional if "SL" aperture types are defined.) A seasonal efficiency may be entered to reflect the type of heat source. Excess heat can be naturally vented whenever the outside air temperature is below the cooling setpoint. The vent areas and distance between the vents are user specified.

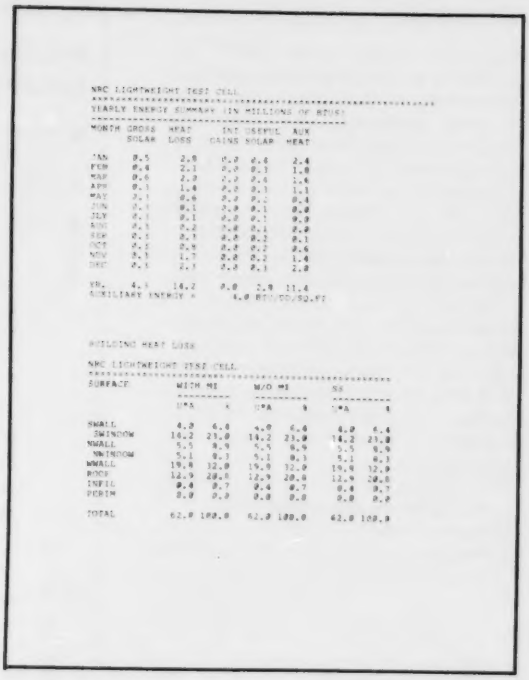
The weather data file requires monthly values of average insolation, ground reflectance, average temperatures, wet bulb temperatures, ground temperatures, "degree-day coefficients" and "wind parameters". These last two items may be calculated by the program using the average temperatures and monthly average windspeeds respectively. Optional but recommended input are the monthly maximum and minimum temperatures. The user must obtain, enter and save (on disk) the weather data for each climatic site of interest.

SUNPAS provides the user with several levels of output detail;

i) monthly and annual auxiliary energy requirements, tabulated or displayed as a bar graph;
ii) "Intermediate Values" of SLR, SSF etc.;
iii) "Heat Loss Breakdown" by building component
iv) and "Solar Gains Breakdown" for each solar aperture.

(See figure 3.8.2 for typical output tables.)

The SUNOP part of the Solarsoft SUNPAS/SUNOP package performs various economic analyses, including; life cycle costing and building envelope costs. The cost per sq. ft. of each envelope type must be entered into a "library", SUNOP can also calculate incremental parametric runs such that the user can optimize a specific feature (such as window size). Only buildings that have no "SL" aperture types in their descrp-tion can be analysed using SUNOP.



NBC LIGHTWEIGHT TEST CELL

YEARLY ENERGY SUMMARY (IN MILLIONS OF BTUS)

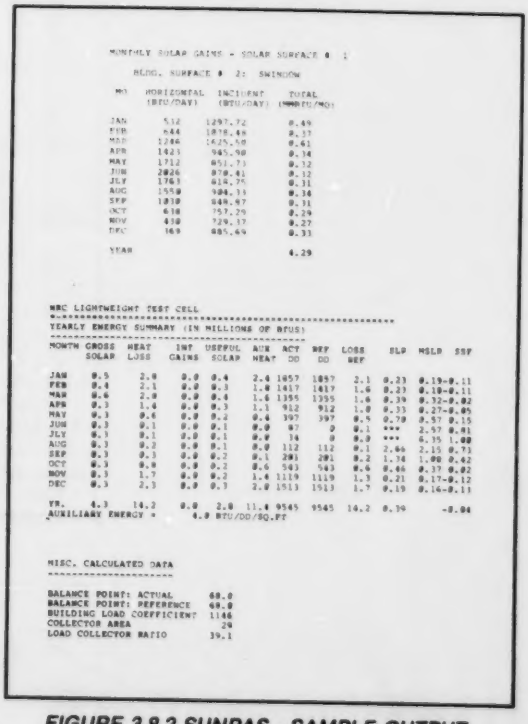
MONTH	GROSS SOLAR	HEAT LOSS	INT GAINS	USEFUL SOLAR	AUX HEAT
JAN	0.5	2.8	0.0	0.4	2.4
FEB	0.4	2.1	0.0	0.3	1.8
MAR	0.6	2.8	0.0	0.4	2.4
APR	0.3	1.6	0.0	0.3	1.3
MAY	0.3	0.6	0.0	0.2	0.4
JUN	0.1	0.1	0.0	0.1	0.0
JLY	0.1	0.1	0.0	0.1	0.0
AUG	0.1	0.2	0.0	0.1	0.0
SEP	0.2	0.3	0.0	0.2	0.1
OCT	0.5	0.8	0.0	0.2	0.6
NOV	0.3	1.7	0.0	0.2	1.4
DEC	0.3	2.3	0.0	0.3	2.0
YR.	4.3	14.2	0.0	2.9	11.4

AUXILIARY ENERGY = 4.0 BTU/DD/SQ.FT

BUILDING HEAT LOSS

NBC LIGHTWEIGHT TEST CELL

SURFACE	WITH MI		W/O MI		SS	
	UFA	%	UFA	%	UFA	%
SMALL SWINDOW	4.0	6.4	4.0	6.4	4.0	6.4
NWALL	14.2	23.0	14.2	23.0	14.2	23.0
NWINDOW	5.5	8.9	5.5	8.9	5.5	8.9
WWALL	5.1	8.3	5.1	8.3	5.1	8.3
WWALL	19.8	32.0	19.8	32.0	19.8	32.0
ROOF	12.9	20.8	12.9	20.8	12.9	20.8
INFIL	0.4	0.7	0.4	0.7	0.4	0.7
PERIM	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	62.0	100.0	62.0	100.0	62.0	100.0



MONTHLY SOLAR GAINS - SOLAR SURFACE # 1

BLDG. SURFACE # 2: SWINDOW

MO	HORIZONTAL (BTU/DAY)	INCIDENT (BTU/DAY)	TOTAL (MMBTU/MO)
JAN	512	1297.72	0.49
FEB	644	1878.49	0.37
MAR	1246	1625.58	0.61
APR	1423	945.98	0.34
MAY	1712	851.71	0.32
JUN	2026	878.41	0.32
JLY	1763	818.75	0.31
AUG	1598	904.31	0.34
SEP	1310	849.67	0.31
OCT	638	757.29	0.29
NOV	438	729.17	0.27
DEC	169	885.69	0.33
YEAR			4.29

NBC LIGHTWEIGHT TEST CELL

YEARLY ENERGY SUMMARY (IN MILLIONS OF BTUS)

MONTH	GROSS SOLAR	HEAT LOSS	INT GAINS	USEFUL SOLAR	AUX HEAT	ACT DD	REF DD	LOSS REF	SLR	MSLR	SSF
JAN	0.5	2.8	0.0	0.4	2.4	1857	1857	2.1	0.23	0.19-0.11	
FEB	0.4	2.1	0.0	0.3	1.8	1417	1417	1.6	0.23	0.18-0.11	
MAR	0.6	2.8	0.0	0.4	2.4	1755	1755	1.6	0.39	0.32-0.82	
APR	0.3	1.6	0.0	0.3	1.1	912	912	1.0	0.33	0.27-0.05	
MAY	0.3	0.6	0.0	0.2	0.4	397	397	0.5	0.79	0.57 0.15	
JUN	0.3	0.1	0.0	0.1	0.0	87	0	0.1	***	2.57 0.91	
JLY	0.3	0.1	0.0	0.1	0.0	34	0	0.0	***	6.35 1.00	
AUG	0.3	0.2	0.0	0.1	0.0	112	112	0.1	2.66	2.15 0.73	
SEP	0.3	0.3	0.0	0.2	0.1	281	281	0.2	1.76	1.00 0.62	
OCT	0.3	0.8	0.0	0.2	0.6	543	543	0.6	0.46	0.37 0.02	
NOV	0.3	1.7	0.0	0.2	1.4	1119	1119	1.3	0.21	0.17-0.12	
DEC	0.3	2.3	0.0	0.3	2.0	1513	1513	1.7	0.19	0.16-0.13	
YR.	4.3	14.2	0.0	2.8	11.4	9545	9545	14.2	0.39	-0.04	

AUXILIARY ENERGY = 4.0 BTU/DD/SQ.FT

MISC. CALCULATED DATA

BALANCE POINT: ACTUAL	68.0
BALANCE POINT: REFERENCE	68.0
BUILDING LOAD COEFFICIENT	1146
COLLECTOR AREA	29
LOAD COLLECTOR RATIO	39.1

FIGURE 3.8.2 SUNPAS - SAMPLE OUTPUT

ACCURACY:

The annual energy consumptions, as predicted by SUNPAS, compared well with the estimated consumptions for the NRC Lightweight, Heavyweight, Trombe wall and Alberta Energy Consumption test cells (see figure 3.8.3). Examination of the predicted consumptions for each month, however, reveals that the program overestimates the energy consumption in the Trombe wall test cell in the spring and fall months.

Less consistent results were obtained for the NRC Sunspace test cell, possibly due to the limited number of SLR sunspace configurations available to the user. There was also a poor comparison (as with all the programs) between the results predicted by SUNPAS and the estimated annual energy consumption of the Albera Passive Solar test cell.

PROGRAM ACCURACY
SUNPAS

■ -NRC DIRECT GAIN CELL, LIGHTWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
▲ -NRC DIRECT GAIN CELL, HEAVYWEIGHT CONSTRUCTION, GLASS TO FLOOR RATIO .09
● -NRC TOMBE WALL TEST CELL
□ -NRC SUNSPACE TEST CELL
△ -ALBERTA TEST HUT, ENERGY CONSERVATION MODULE, GLASS TO FLOOR RATIO .12
○ -ALBERTA TEST HUT, PASSIVE SOLAR MODULE, GLASS TO FLOOR RATIO .24

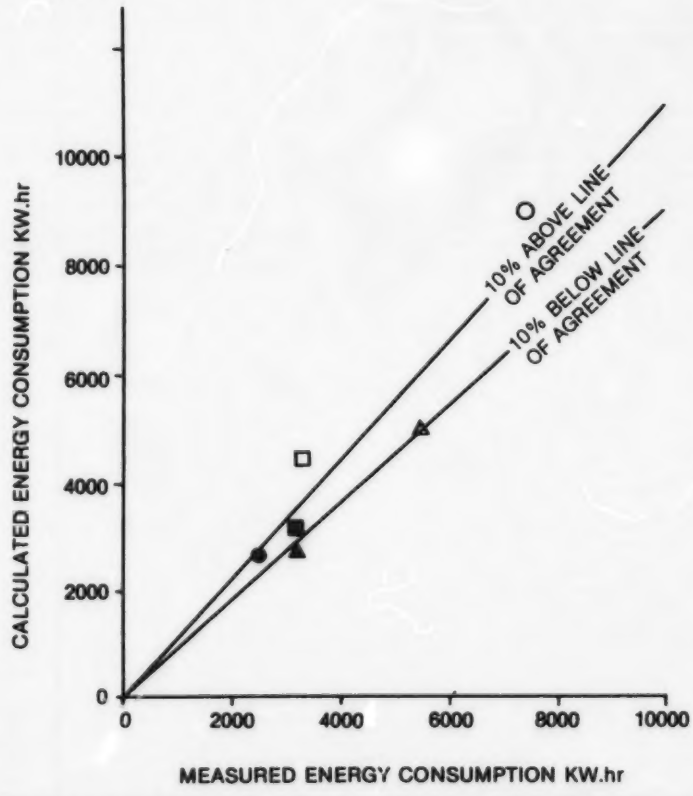


FIGURE 3.8.3 SUNPAS - PROGRAM ACCURACY

EASE OF USE:

One of the first tasks the new user must perform is "backing up" (making copies) of the program disks. This must be done using the utilities disk, however the instructions are not clear for its use. The utilities disk contains the disk operating system which allows disks to be formatted and files to be copied, deleted. etc.

SUNPAS's copy-protection system (which prevents unauthorized copies of the master disk from being made) requires the user to insert the master disks to "boot' (load in and initialize) the program. The backup disk can only be used once the program has been booted in. Since there are two main program disks, the user often finds himself inserting, removing and re-inserting disks, which is inconvenient.

SUNPAS provides clearly titled and well displayed "menus" which allow the user to easily find his way through the program. A help facility (made available by typing "?") further explains the options on each menu.

The program has a "full-screen date entry" facility providing the analyst, for the most part, with a quick and easy method to enter the building description. A "beep" is given for invalid date, there are no messages to what a valid entry might be, e.g. the number ".5" is an invalid entry, "0.5" must be entered. The procedure for editing an existing file is awkward and inconsistent with the data entry procedure, thus hindering the user's ability to quickly make changes to a model.

All five evaluators had problems using the program and initially it was thought that there were bugs in the program. Some of the problems encountered included:

- unable to move the cursor. The program needed to be reinitialized to get around the problem, and all unsaved data was lost.
- during data entry, an error message, ("... floating point error ... press space bar to continue.") was received which resulted in the program "crashing" and data being lost.
- introducing a night setback strategy or using two values (day and night) for internal gains in the description of the building model had no effect.
- no error message was given when an aperture name was not indented (as required) which resulted in the program crashing and data being lost.

The evaluators have since been informed by the program authors that these problems and others are caused by using invalid wall types and "SLR" aperture types (instead of "SL" types) for the building being described. However, similar problems are still being encountered and the cause is not immediately apparent. A new user will find this frustrating.

Much of the information required to describe a model is provided in the documentation, but it is often hard to find. More dividers with tabs would help. The user can get used to the way the manual is laid out but for the new user, finding information is very time-consuming. The reader is often referred to the appendices, but specific appendices are not referenced and page numbers are not given. Initially it is not apparent where the appendices begin and end. The Passive Solar Design Handbook (Reference 2) is recommended reading and should be read as the SLR methodology is not discussed in the manual. The handbook is often referenced, but again sections and page numbers are not given.

CONCLUSIONS & GENERAL COMMENTS:

Potentially SUNPAS could be a very useful design tool, but currently the program has some shortcomings;

- the program's copy-protection system makes it awkward to use.
- data edit procedures could be improved.
- the program documentation does not explain the use of the utilities disk well; it could be better organized and is incomplete if the analyst does not have access to the Passive Solar Design Handbook;
- invalid data entries are not always brought to the user's attention and sometimes cause the program to crash.

On the positive side, SUNPAS is inexpensive to purchase (approximately $400 U.S.) and is apparently capable of producing fairly accurate results.

4 PROGRAM COMPARISON

For the purpose of presenting as much of the information obtained from the evaluations as possible, data have been assembled in matrix form permitting a potential user to view the overall strengths and limitations of each program fairly quickly and easily.

However, this method of presentation does limit the extent of information that can be presented. The degree or ease to which a particular program can accommodate specific features is generally not presented in this section. This qualitative information is addressed in Section 3.

4.1 TECHNICAL SCOPE

The information presented in Table 4.1.1 (Technical Scope) shows a wide variation in the number of features each program can model. The simpler programs or the programs not particularly oriented towards passive solar features, notably, CMHC2 and HOTCAN, are somewhat limited in technical scope. The programs capable of hourly simulations (CALPAS3, ENERPASS and SERI-RES) have many features, allowing the user to model many different design strategies.

TECHNICAL SCOPE	CALPAS3	CASAMO	CMHC2	ENERPASS	F-LOAD	HOTCAN	SERI-RES	SUNPAS
A ENVELOPE COMPONENTS								
Above Ground Exterior Surfaces:								
Complex Shape	•				•		•	•
Any Orientation	•	•	•	•	•	•	j	•
Any Tilt	•	•		a	•		•	•
Below Grade Surfaces	•	b	•	•	•	•	•	•
Shading:								
Window Setbacks/Overhangs & Fins	•	•		•	c	c	•	c
Detached (e.g. other Buildings)		•	o		o		•	o
Scheduled Window Shading	•			•			•	o
Variable Window Insulation	•	•		•	•	•	•	•
Mass Walls:								
Unvented	•			•			•	•
Naturally Vented	•	•		•	•		•	•
Mechanically Vented	•							
B INTERIOR SPACE COMPONENTS								
Space Conditioning:								
Heated	•	•	•	•	•	•	•	•
Cooled	•			•	•		•	•
Unconditioned	•	•	•	•	•		•	
Supplementary Mass:								
Non-isothermal	•	d	o	•	o	o	•	•
Isothermal (e.g. Water Walls)	•			•			•	k
Isolated (e.g. Rockbeds)	•						•	•
Phase Change Material				•			•	
C SPACE ACTIVITIES								
Internal Gains:								
Sensible	•	•	•	•	•	•	•	•
Latent	•				s		•	
User Scheduled	•			•			•	o

TABLE 4.1.1

TECHNICAL SCOPE	CALPAS3	CASAMO	CMHC2	ENERPASS	F-LOAD	HOTCAN	SERI-RES	SUNPAS
D HEATING AND AIR CONDITIONING								
System type:								
Central Heating	•		•	•	•		•	
Individual Room Controlled	•				•		•	
Air Conditioning	•			•	•		•	
Heating Sources:								
Conventional Furnace	o		o	o	•	e		o
Furnace with Vent Damper			o		•			
Flueless/Condensing Furnace			o	o	•			
Heat Pump					•			
Direct Electric	•		•	•	•	e	•	•
Domestic Hot Water Heating				•	•	e		
Special Systems:								
Exhaust/Ventilation	o		•	•	•	•	•	
As above with Heat Recovery			•	•	•			
Fan Air Mixing Between Zones	•			•			•	
Fanned Air to Rockbed Storage	•						•	
Control Systems:								
Night Set-back	•		•	•	•		•	•
Excess Heat Venting	•		•	•			•	l
E SPECIAL FACILITIES								
Fuel Costs	•		•	•	•	•		•
Capital Costing			•					m
Life Cycle Costing			•		•			m
F WEATHER DATA								
Number of Canadian Locations	f	0	f	150	93	68	0	0
Facility to Format Weather	f	g	g	•	g	g	h	g

TABLE 4.1.1 (continued)

Table 4.1.1 Notes:

- • *Program can model feature.*
- o *Program can model feature, but not in an explicit or rigorous manner.*
- a *For sunspace surfaces only.*
- b *Basement is treated as an unconditioned space.*
- c *Overhangs only.*
- d *Program assumes infinite mass, i.e., no overheating perfect solar utilisation.*
- e *May be specified but used only for an economic analysis.*
- f *Supporting agency is in process of formatting Canadian weather data.*
- g *User may enter his own monthly data.*
- h *Weather files may be reformatted from Atmospheric Environment Service (AES) weather tapes.*
- i *None of the programs is capable of modelling building self-shading.*
- j *North, South, East, West, Southeast and Southwest orientations only.*
- k *User may choose from 15 SLR waterwall systems.*
- l *Excess heat is naturally vented whenever the outside air is below the cooling setpoint. Vent areas and the distance between the vents is entered.*
- m *Must use the SUNOP part of the Solarsoft SUNPAS/SUNOP package.*

4.2 TECHNICAL ACCURACY

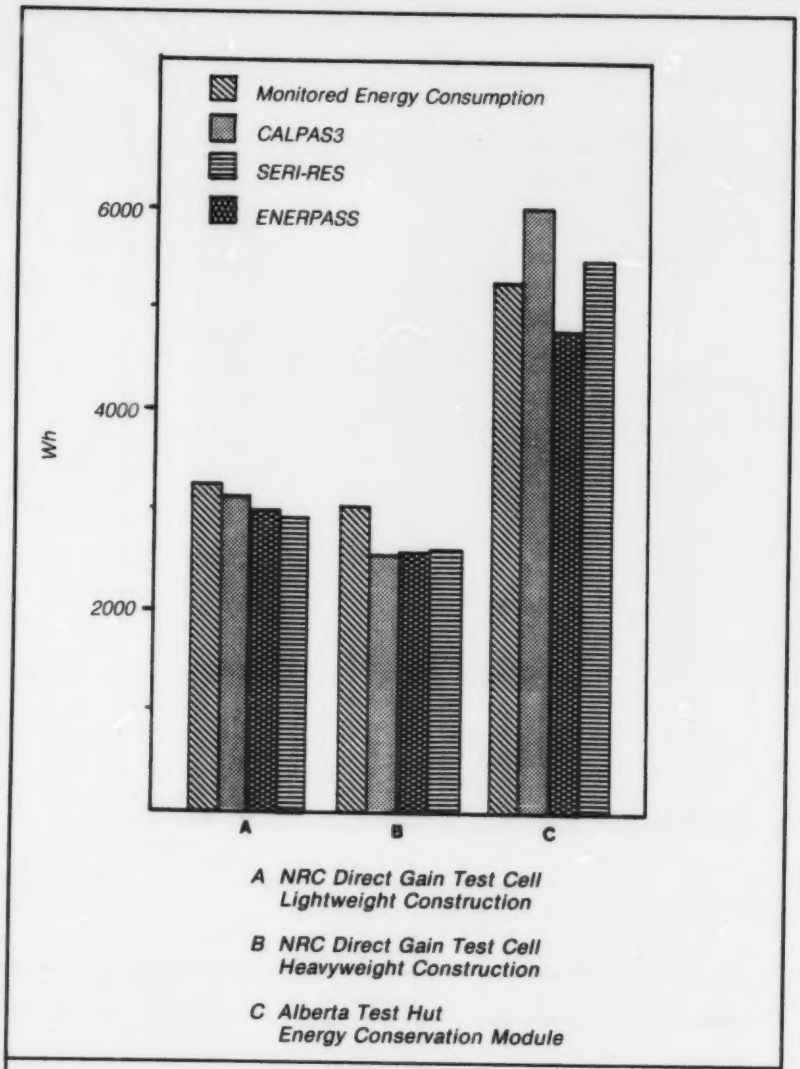
A summary of sensitivity and potential accuracy for the programs tested is given in Table 4.2.1. Generally speaking the hourly programs have sensitivity to a wider range of physical parameters affecting energy use than do the non-hourly programs. However, in specific instances, such as infiltration modelling, CMHC2, a non-hourly program, is sensitive to more of the features known to affect infiltration than are the hourly programs. The information provided in this table should, where possible, be complemented by knowledge of the actual accuracy obtained through the comparison of predicted and monitored data since the mere fact that a program is sensitive, to say wind effects, in no way guarantees that the effect is correctly simulated.

SENSITIVITY & POTENTIAL ACCURACY		CALPAS3	CASAMO	CMHC2	ENERPASS	F-LOAD	HOTCAN	SERI-RES	SUNPAS
A ENVELOPE COMPONENTS									
Thermal Bridging	j		o	o			o		
Mass (Transient Thermal Effects)		•						•	
Window/Glass Characteristics	a		b		b			•	
Absorbed Solar Radiation	c	•		•	•	•			•
B BELOW GRADE SURFACES									
Basement Geometry					•	•	•		
Insulation (Level & Placement)		d		•	•	•	•	•	d
Soil Temperatures		•		•	•		•	•	•
Soil Conductivity		o		•				o	•
C INFLITRATION									
Building Geometry & Leakage Location		•		•					k
Stack Effect		•		•				•	k
Wind Effect (Speed & Direction)				•				•	k
Furnace Operation				e					
D INTERIOR SPACE									
Interior Mass		•		o	•	o	o	•	•
Interior Mass Placement		•			o			•	•
Number of Zones		3f	1	6g	3h	1	1	15i	2i
Zone to Zone Heat Transfer:									
Conduction		•		•	•			•	•
Natural Air Movement		•							
Mechanically Induced Air (Fans)		•			•			•	
Radiation (Solar)		•						•	
E OTHER									
Comfort (Radiant Temps. Considered)		•						•	
Variable Temps. (e.g. Setback, Swings)		•		•	•	•		•	•
Part Load Efficiencies of Equipment						•			
Humidification/Dehumidification						•		•	

TABLE 4.2.1

Table 4.2.1 Notes:

- • *Program is sensitive to feature*
- o *Program is sensitive to feature, but does not model explicitly.*
- *a As opposed to simplified analysis using shading coefficients.*
- *b Adjusts transmission and conduction to account for window frame details.*
- *c Solar radiation absorbed by the exterior surfaces.*
- *d Insulation level only.*
- *e Allowance made for the effect the following furnace types have on infiltration: conventional, conventional with stack damper, and condensing.*
- *f Two of which must be a sunspace and a rockbin zone.*
- *g Four of which must be a basement, crawlspace, unheated porch, and unheated garage zone.*
- *h One of which must be a basement zone.*
- *i Includes up to five rockbin zones.*
- *j Thermal bridging may be modelled by all programs (assuming parallel heat flow) by external calculation (to adjust overall U-values) or by defining "other" wall areas with appropriate U-values.*
- *k SUNPAS can model natural ventilation, see item 1 in Table 4.1.1 Notes.*
- *l One of which must be a sunspace.*



A NRC Direct Gain Test Cell
Lightweight Construction

B NRC Direct Gain Test Cell
Heavyweight Construction

C Alberta Test Hut
Energy Conservation Module

FIGURE 4.2.2

Selected information concerning actual accuracy is presented in Figures 4.2.2 to 4.2.5.

Due to the limited amount of continuous monitored data available, only those programs capable of producing hourly results (CALPAS3, ENERPASS and SERI-RES) were compared against actual monitored data (Figure 4.2.2). All other programs had their monthly results compared against data generated by those hourly programs that matched the monitored data in a satisfactory manner, i.e. the three programs that were tested plus ENCORE, NRC's experimental simulation program. The generated data were used to estimate the seasonal (October-April) energy consumption for each test cell. Because of the uncertainty of the accuracy of the estimated consumption, a "confidence range" was calculated, within which it was assumed the true consumption would probably lie. This range is represented by the shaded area on figures 4.2.3 to 4.2.5.

Figure 4.2.2 gives a comparison of calculated and actual monitored energy consumption for the 3 hourly programs for the Lightweight and Heavyweight NRC Test Cells and the Alberta "Energy Conservation" Test Hut. Using accumulated energy consumption as a basis for comparison, such as used in Figure 4.2.2, can be misleading since self-cancelling errors can give a wrong impression of accuracy.

Figures 4.2.3 and 4.2.4 show annual energy consumptions for all seven programs for the NRC Lightweight and Heavyweight Test Cells. Predicted annual consumptions are fairly consistent between the various programs. However, the figures also show that each of the program's calculated energy consumption is generally lower than the estimated confidence range. This is particularly prevalent for the Heavyweight Test Cell. Self-cancelling differences in monthly consumptions are not illustrated in the graph. These differences are especially evident in those programs using simplified methods for estimating the effect of thermal capacity, such as CASAMO and F-LOAD. These programs tend to underestimate energy consumption in spring and fall while overestimating the consumption in the colder months. This is most pronounced in the case of the Heavyweight Test Cell.

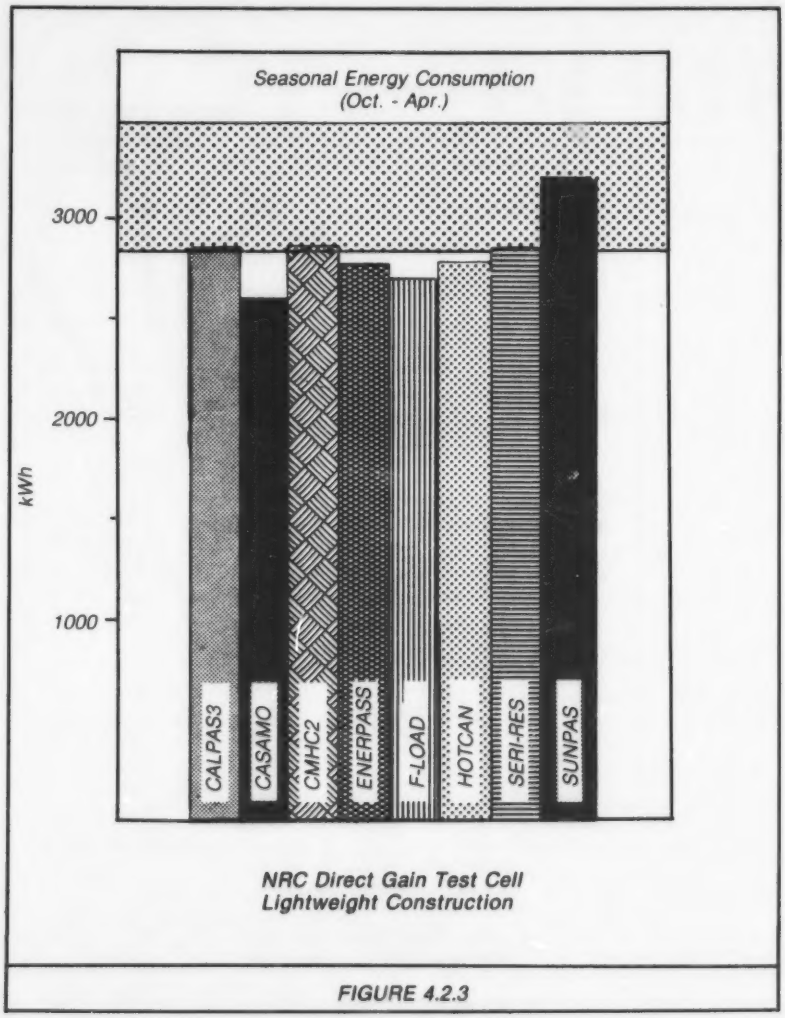


FIGURE 4.2.3

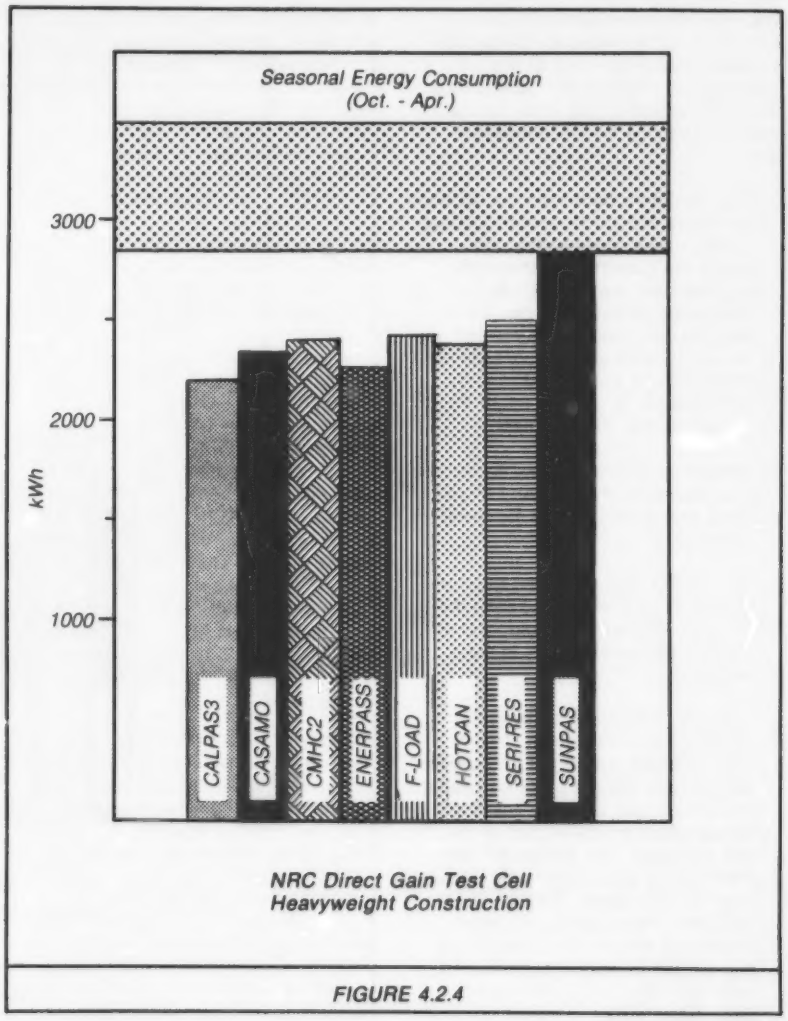


FIGURE 4.2.4

NOTE: *The 'confidence range' for the estimated seasonal energy consumption (represented by the shaded areas on the graphs) was generated by the hourly programs that best matched the monitored data.*
Example: Figure 4.2.2 shows that all three programs underestimated the energy consumption for the NRC Heavyweight Test Cell. Since the shaded area is based on the results of these programs it follows that the seasonal consumption will also be underestimated by a similar amount.

The calculated annual energy consumptions for the Alberta Energy Conservation Hut (Figure 4.2.5) are presented to contrast the consistency of results shown in the other figures. Possible reasons for the differences are:

i) The monitored data from the Alberta Test Huts include basement heating energy unlike those at the NRC where the basement is thermally isolated from the test cell. In a parametric analysis the basement was removed and the calculated results showed greater consistency indicating basement modelling in some programs to be a major contributor to lack of consistency.

ii) Remaining differences are tentatively attributed to the handling of solar gains specifically for the following reasons:

a. The Alberta Test Huts had greater glazing to floor area ratio than did those at NRC which would tend to magnify any weaknesses in solar simulation.

b. Typically, the simple analytical methods used for splitting hourly total radiation into direct and diffuse components did not produce results that match well with the direct and diffuse radiation measured at the test cell sites. The results for the Alberta huts were noticeably poorer than the NRC ones. Further, SERI-RES, the only program that used (indirectly) actual monitored direct and diffuse components produced results closest to the monitored data. Results from a sensitivity study (Reference I4) indicated that measured values, or more sophisticated analytical methods for deriving the direct and diffuse component, are necessary for good modelling.

c. The fact that the Alberta huts had window overhangs while the NRC ones did not may have some contribution to lack of consistent modelling but there has been no attempt to substantiate it to date.

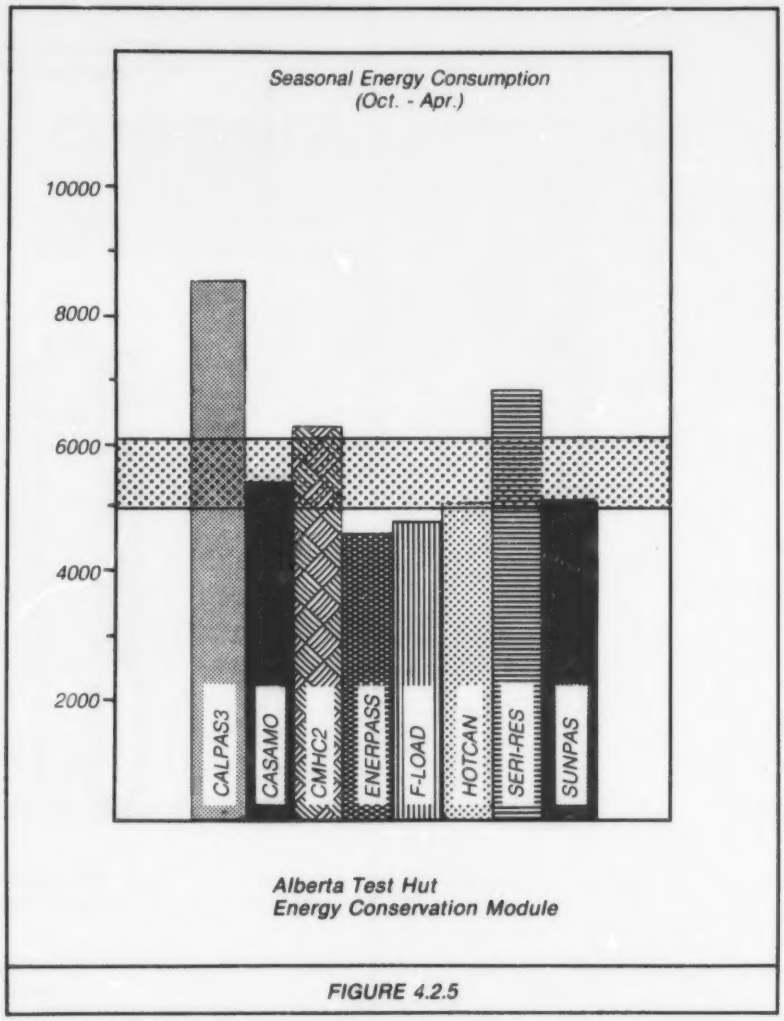


FIGURE 4.2.5

Primarily due to space limitations not all the comparisons made to check accuracy are included in this section. Complete information can be found in Section 3 for comparison with the NRC Trombe Wall and Sunspace Test Cells and for the Alberta Passive Test Hut. Very briefly the main conclusions from these additional tests are:

1. From the Trombe wall the three hourly programs matched monitored data fairly consistently; however, it appears that for the monitored period used for the comparisons, conditions were such that there would be no thermosiphon action in the Trombe wall. Over a complete year (for which monitored data were not available) and with the exception of CASAMO, those programs capable of modelling a Trombe wall did so with reasonable consistency (the results ranged, excluding CASAMO, from 2247 to 2669 kWh).

2. Comparisons with the Alberta Passive Solar Test Hut yielded similar (and inconsistent) results to those presented for the conservation hut.

3. A significant problem arose with the sunspace comparisons in that none of the programs capable of sunspace modelling could explicitly model the method of over-temperature ventilation control used in the test facility making it difficult to form conclusions about accuracy over those periods when the sunspace overheated. In fact, it was not possible to model these periods at all without first looking at the available monitored data to determine the maximum recorded sunspace temperature and using this temperature in the simulations. Despite these problems, the three hourly programs matched the hourly data with reasonable consistency for energy, though less than they did for the other NRC test cells. Temperature predictions, however, were not particularly good. For the annual simulations the predicted consumptions of these hourly programs were within the range of 2714 to 3452 kWh. The non-hourly programs offering sunspace simulation produced results of 2359 kWh. (CASAMO) and 4421 kWh. (SUNPAS).

4.3 EASE OF USE

Presented in Table 4.3.1 is a summary of those features considered to contribute to ease of use in each of the programs tested. An additional, more subjective evaluation of ease of use along with the time taken to collect and prepare input data is given in Table 4.3.2. Three groups of evaluators rated each aspect on a scale of I to 5, 5 being the highest rating; the average response of the evaluators is given in the matrix. It should be noted that, for the most part, the evaluators were new users of each program (the exceptions being the University of Montreal evaluators of CASAMO and HOTCAN, and the Energy Building Group evaluator of HOTCAN).

Consistency of the calculated results, which can be considered as an indicator of ease of use, was reviewed. The lack of a large number of users makes generalisations difficult but indications are that:

i) simple structures such as the Test Cells and simple houses which can be modelled explicitly are modelled with greatest consistency by those programs demanding least input, i.e. the non-detailed (non-hourly) programs can be considered "easier to use" in these cases.

ii) More complex structures, however, are modelled with least consistency by the simpler programs. For difficult and involved problems more detailed programs can be considered easier to use in the sense that it is easier to get an accurate result since calculations (by the program) replace the guesswork and approximations required using the "simpler methods".

iii) Even the so-called simple programs cannot be guaranteed to produce sensible results with inexperienced users or without very careful input data preparation and output data inspection.

iv) While the use of defaults make complex programs easier to use by lessening the input burden, it is extremely dangerous to take the defaulted values as always being reasonable.

EASE OF USE	*CALPAS3*	*CASAMO*	*CMHC2*	*ENERPASS*	*F-LOAD*	*HOTCAN*	*SERI-RES*	*SUNPAS*
A USER INTERFACE								
Prompts:								
Both Detailed & Terse		•		•				
Range of Responses Displayed			•					
Defaults Displayed			•		•	•	•	
Correct Format Displayed		•	•				•	
Input Format Flexibility:								
Ignores Blanks	•	•	•	•	•			
Upper & Lower Case Allowed	•	•	•	•	o			•
Multiple Response on One Line	•		•	•	•		•	
Feedback on Input Command e	•	•	•	•	•	•	•	•
Full Screen Data Entry			•					o
Dynamic Defaults a	•	•	•					
Editing:								
Line Editing of Input	•	•	•	•	•	•	•	•
Editing Any Point in Data Entry f				•	•		•	•
Sequence Control:								
Menu Driven		•	•			•		•
Query		•	•			•		
Command Language	•			•	•		•	
Interrupt (By User):								
From Any Level in Program				•	•		•	•
From Selected Points in Program	•	•	•			•		
Continue Facility	o	•	•	o	•	•	o	
Can Interrupt for:								
Saving Data		•	•	b	•	•	•	•
Restoring "Saved" Data	•	•	•	b	•	•	•	•
Abort Processing			•	•	•	•	•	•
Skip Forward/Backward		•	•	•	•		•	•
Display Current Data		•	•	•	•		•	•
B INPUT DATA REQUIREMENTS								
Number of Parameter Types:								
Total	180	59	75	124	125	35	110	49
Require Response - No Defaults	18	25	29	16	50	35	30	21
Reference Information Provided	6	59	20	6	5	0	7	16

TABLE 4.3.1

EASE OF USE	CALPAS3	CASAMO	CMHC2	ENERPASS	F-LOAD	HOTCAN	SERI-RES	SUNPAS
C OUTPUT DATA								
Output to Verify Modelling Intent:								
Out-of-"Normal Range" Variables	•		•	•	•		•	
Errors Identified	•		•	o	o		•	•
Inconsistent Data			•	•			•	•
Output Frequency:								
Hourly	•				•		•	
Daily	•						•	
Monthly	•	•	•	•	•	•	•	•
Annualy	•	•	•	•	•	•	•	•
User Specified Output Period	•			•			•	
Calculated Values Output:								
Heating Energy Consumption	•	•	•	•	•	•	•	•
Cooling Energy Consumption	•			•	•		•	•
DHW Energy Consumption			•	•	•	c		
Electricity Consumption	•		•			c		
Space Temperatures	•			•			•	
Peak Heating Load	•			•			•	
Peak Cooling Load	•			•			•	
Output Format								
Graphical					•	•		•
Tabular	•	•	•	•	•	•	•	•
Units:								
SI		•	•	•	•	•	•	
Imperial	•		•		•	•	•	•
Parametric Runs Output Together		•	•			•		
D DOCUMENTATION EVALUATION			d			d		
User Help:								
Program Abstract Provided	•	•		•	•		•	•
"Quick" Reference Guide Provided								
Hardward/Software Requirements	•	•					•	
Engineering Procedures:								
Identified & Referenced	•	•		•	•		•	•
Capabilities/Limitations Discussed		•		•	o		•	
Computational Procedures:								
Outline of Major Steps		•						
Limitations Discussed		•		•	o		•	
Cost vs. Accuracy	•	•					•	
Error Messages Listed & Explained							o	

TABLE 4.3.1 (continued)

Table 4.3.1 Notes:

- • *Program can accommodate feature.*
- o *Program can accommodate feature, but it is difficult to use, inconsistent, or incomplete.*
- a *Defaults that vary according to a user response, e.g. CALPAS3 defaults the thermal capacity of the house to be (1.5 x (floor area) + 1000) BTU/deg.F.*
- b *User must exit and "Log" back into program to save data.*
- c *Only fuel costs are output.*
- d *Programs are currently under development (CMHC2) or revision (HOTCAN), documentation not available at this time.*
- e *Program displays a message or prompt to inform the user of the implications of his last command.*
- f *Program allows the user to interrupt the data entry process at any point to go back and edit previously entered data.*

EASE OF USE (Subjective Aspects)		CALPAS3	CASAMO	CMHC2	ENERPASS	F-LOAD	HOTCAN	SERI-RES	SUNPAS
A USER INTERFACE									
General:									
Instructions (Easy to Understand)		3	5	4	3	4	4	3	4
Human Memory Demands		3	4	5	3	4	5	3	4
User Orientation	a	3	4	4	3	3	4	3	5
Prompts (Clearly Worded)		3	5	4	2	3	4	4	4
Error Checking:									
Understandable Messages		4	2	5	1	3	3	3	2
Positive/Constructive Messages		4	2	4	1	3	3	3	3
Non-catastrophic Results		4	2	4	1	4	4	3	2
Cause Easily Corrected		3	5	5	2	4	4	4	3
Ease of Learning Command Language		3	5		3	4		3	
Usefulness of Help Facility		3	2		3	2			4
Program Response Time	b	2	4	5	3	4	5	2	4
Data Input Time (Minutes)	f	60	60	20	50	20	15	140	35
B INPUT DATA REQUIREMENTS									
Data Collection Time (Hours)	c	7	7	7	7	7	7	7	7
Data Preparation Time (Hours)	f d	7	1	1	6	0.5	0.5	5	2
C OUTPUT DATA									
Easy to Read (Avoids Cryptic Codes)		3	4	4	4	4	4	4	4
Suitable for Inclusion in Reports		3	4	3	4	4	3	3	3
D DOCUMENTATION EVALUATION				e			e		
Information & Reference Data:									
Sufficient for Most Applications		4	4		3	4		4	4
Easily Found		5	4		4	4		1	3
Examples:									
Explain Input Data Preparation		4	4		2	4		2	3
Explain Output Data Interpretation		4	4		3	4		2	4
Readibility:									
Clear & Concise (Avoids Jargon)		3	4		4	4		3	4
Easy Reading Format		4	4		4	3		2	3

TABLE 4.3.2

Table 4.3.2 Notes:

All aspects are rated on a scale of 1 to 5 (except where units of time are noted), 5 being the highest score.

a Response to the question - Does the user know what he is doing in the program and what to do next?

b Response to the question - Is the program response time perceived as quick (calculated results obtained in seconds would rate a 5) or slow?

c The time required to abstract the necessary information and reference material such as wall areas and U-values (in this case, for a fairly complex house). Hence, this time (7 hours) is approximately the same for all programs.

d The time required to carry out non-trivial calculation to obtain information in the format required by the program (e.g. calculating wall areas from wall dimensions would be classified as trivial).

e Programs are currently under development (CMHC2) or revision (HOTCAN), documentation not available at this time.

*f Example, CALPAS3 vs. SERI-RES, description of the same building (particularly a complex or exotic design). **Data Preparation Time**: CALPASS will typically take longer than SERI-RES due to the requirement for more external calculations and the use of cryptic input parameter names. **Data Input Time**: SERI-RES will typically take longer to enter input data than CALPAS3 due to SERI-RES's interactive and somewhat awkward to use, input procedure. Once the user has prepared CALPAS3's input data (i.e., filled in the input forms) the data can be typed in much quicker, exactly as it appears on the forms, using an IBM-PC compatible text editor.*

COST		CALPAS3	CASAMO	CMHC2	ENERPASS	F-LOAD	HOTCAN	SERI-RES	SUNPAS
Initial Purchase Cost ($)	a	795	1000	b	695	425	55	1100	400
Hardware Costs ($1000's)	c	10	8	10	3	8	8	3	8
Weather Data Costs ($)	h	5	—	—	100	—	—	e	—
Learning Costs (Days)	f	2	1.5	1	2.5	1	0.5	3.5	2
Engineering Costs:	g								
Data Preparation (Hours)		7	1	1	6	0.5	0.5	5	1.5
Input Time (Minutes)		60	60	20	50	20	15	140	30
Output Analysis (Minutes)		15	10	15	10	15	10	15	10
Running Costs:	d								
Computations ($)		—	—	—	10	—	—	100	—
Associated Services ($)		—	—	—	2	—	—	15	—

TABLE 4.4.1

Table 4.4.1 Notes:

a Purchase cost for CALPAS3, F-LOAD, SERI-RES and SUNPAS is in US dollars.

b Program currently under development - purchase cost not available.

c The hardware cost for ENERPASS and SERI-RES reflect the cost for a terminal (for communication with a main-frame computer) and printer whereas the other program hardware costs reflect the cost for a micro- computer and the necessary peripherals (required amount memory and disk drives, screen, printer, etc.).

d Extremely machine and computer bureau dependent, but figures reflect order of magnitude only. Discount rates for overnight computations are not considered.

e User is required to reformat existing weather tapes.

f Time required for new user to successfully complete his first model (other than running any sample models).

g Based on the time required to model a fairly complex house.

h Weather costs are for additional locations. Five sites are received with the purchase of CALPAS3 and one site with the purchase of ENERPASS.

4.4 COSTS

Presented in Table 4.4.1 are the direct, indirect and associated costs for each of the programs tested.

The potential user might be tempted to focus on only the direct costs (purchase cost, weather data costs, and running cost) and the indirect costs (hardware, etc.). However, the associated costs, presented in units of time, can, depending on the extent of use, be equally if not more important.

APPENDIX A
GLOSSARY OF TERMS

Absorptance
See Solar Absorptance.

Attached Sunspace
See Sunspace.

Base Temperature
A temperature used in the calculation of degree days, theoretically the average outdoor temperature above which heating is not required. In Canada degree days are usually reported to a base of 65°F or 18°C.

Condensing Furnace
A high efficiency furnace in which the flue gases are cooled to such an extent that water vapour is condensed out of the gases giving up the latent heat to the heating system. Such furnaces operate without a conventional chimney, flue gases being directly vented at low level.

Command Language
A vocabulary of words and mnemonics used by some programs to describe the (building) model.

Degree Days
See Heating Degree Days.

Default Value
Or "default" for short. Building description parameters that have predefined values and are used by the program if no user specified value is entered. See also Dynamic Default.

Diffuse Radiation
The component of incoming short wave radiation that has been scattered by atmospheric molecules and particles. The diffuse radiation is uniformily intense from all points of the sky. Typically solar algorithms assume that the transmission of diffuse radiation is not affected by external shading.

Direct Gain
A design strategy in which solar gain is allowed to be transmitted directly into the occupied space. The absorbed solar radiation eventually reappears as heat, thus reducing the auxiliary heating energy consumption.

Direct Normal Radiation
The component of solar radiation that is received directly from the sun, on a surface perpendicular to the rays. Normally solar algorithms will assume that external shades will block out this component.

Dynamic Default
Building description parameters that are redefined and vary according to the users' previous responses, e.g. the default for ceiling area would be equal to the user's entry for floor area.

Emittance
A measure of the ability of a surface to emit infrared radiation; specifically it is the ratio of the infrared radiation emitted at particular temperature compared to that from a perfect emitter at the same temperature.

Enhanced Direct Gain (Systems)
A design strategy in which solar radiation, reradiated in the direct gain space, is transferred by a fan to thermal storage or to another part of the building.

Flueless Furnace
A furnace which does not require a flue, e.g. condensing furnace, electric furnace. A building without a flue would not have infiltration induced by combustion gases and air rising (or fan-forced) up the flue.

Full Screen Data Entry
A facility in a computer program that allows the user to position the cursor at the appropriate place on a CRT screen to enter data. Normally there is a common subject per screen thus the user may view all the entered data on the screen (and make any necessary changes) before going on to another screen.

Global Radiation
The total (direct and diffuse) incoming shortwave radiation from the whole dome of the sky received on a flat horizontal surface.

Heat Capacity
A measure of the ability of material to store heat; specifically it is the heat stored per degree of temperature rise (Joules/deg. C or BTU/deg. F).

Heating Degree Days
A measure of the severity of the climate over an annual period or "heating season". A building heating consumption can be considered to be roughly proportional to the number of degree days. In Canada a degree day is assigned for every degree which the average daily outdoor temperature falls below the base temperature (see also Base Temperature). Other countries may use slightly different definitions.

Help Facility
A facility in a computer program that provides information, on a specific command or input parameter, when the user "asks" for it.

Indirect Gain
A design strategy in which solar heat is transferred into the occupied space through a conductive or convective medium (such as a thermal storage wall or roof pond).

Infiltration
Heat loss due to the uncontrollable air exchange between heated spaces and the outdoors.

Infrared Radiation
Also referred to as longwave radiation; radiation whose wave length is longer than the wavelengths within the visible portion of the spectrum. This is the predominant type of radiation exchange between building surfaces and objects within a space.

Internal Heat (Gains)
Heat generated inside the building by sources other than the sun or the heating equipment. Would include appliances, lights, and people.

Isolated Gain (System)
A design strategy in which the principle area or device collecting solar radiation is physically separated from the main occupied area. Attached sunspaces double envelope and vented mass wall systems would be included under this classification.

Isolated Storage
Heat storage thermally isolated or remote from the occupied space. Heat is transferred by the thermosiphon effect or by fans (e.g. rockbed storage).

Isothermal Mass
Heat storage devices, typically fluids in containers, in which the heated mass is at a nominally uniform temperature. This uniformity is maintained by convective mixing occuring in the fluid (see also water-wall).

Menu Driven (Software)
Computer programs that display a list of response options available to the user. This allows the user to instruct the computer to go on to another section or module in the program.

Non-isothermal Mass
Not isothermal, see Isothermal Mass.

Parametric Analysis
Comparison of two or more program output data where (normally) one variable of the building description has been changed.

Phase Change Material
Materials that store or release heat by changing phase. Heat, required to change a material from solid to liquid (or liquid to gas), is released when the process is reversed. There is little or no temperature rise (or drop) when a material changes phase thus it is possible to store large amounts of heat energy in the material without allowing the occupied space temperature to rise significantly.

Prompts
A mnemonic, word or message given by a computer program to
i) signify that the program is ready to receive information
ii) instruct the user the type of data (and in the correct form) that should be entered
iii) inform the user on the program options available.

Query Driven (Software)
A method of data entry in which the program prompts the user for an appropriate response (i.e. data).

Sky Radiation
See Diffuse Radiation.

Solar Absorbtance
The fraction of incident solar radiation that is absorbed upon striking a surface. The radiation not absorbed is reflected.

Solar Radiation
Electromagnetic energy emitted by the sun; includes wavelengths in the infrared, ultra-violet and visible portion of the spectrum.

Thermal Network Model
A type of model where the building is described as a series of nodes connected to each other by thermal resistances and thermal capacitances. Each connection can be described by a mathematical equation. Thus the building is described as a series of simultaneous equations which are solved by the computer (typically every hour).

Thermal Storage Mass
Building elements, usually masonry or water in containers, designed to absorb solar heat during daytime hours for release later when heat is needed.

Thermal Storage Wall
Sometimes referred to as a mass wall. A wall of massive material, often placed between the glazing collecting solar radiation and the heated space. Heat is transferred into the space by conduction or conduction and convection in the case of isothermal storage, and, if openings are provided, by natural or mechanical convection. See also Trombe Wall and Water Wall.

Thermal Zone
In the context of computer modelling, a space within a building (or the entire buiding if assumed to be one zone) that is considered to have a uniform air temperature throughout; i.e. there is perfect mixing of all heat gains and losses.

Thermocirculation
Free convection from a warm zone (sunspace or Trombe Wall air space) to a cool zone through openings in a common wall.

Total Radiation
See Global Radiation

Trombe Wall
A naturally vented thermal storage wall.

Ventilation
Desirable and controlled air exchange between inside and outdoors.

Water Wall
A thermal storage wall of water in containers placed between the solar aperture and the heated space is transferred into the space by conduction and convection through the water.

APPENDIX B
REFERENCES

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APPENDIX C
COMMENTS FROM PROGRAM AUTHORS OR SUPPORTING AGENCY

BSG
BERKELEY SOLAR GROUP
Post Office Box 3289
3140 Martin Luther King Jr. Way
Berkeley, California 94703
(415) 843-7600

April 3, 1985

Mr. Doug Grey
Leslie Jones & Associates Inc.
1A - 324 Somerset Street West
Ottawa, Ontario
CANADA K2P-0J9

Dear Doug:

I have reviewed your report "Computer Programs for Passive Solar Residential Design" and I commend you on its thoroughness.

I found the material concerning our program CALPAS3 to be essentially accurate and complete. I would like to add that Berkeley Solar Group is currently working on CALPAS4, a highly enhanced version of CALPAS3. The main features being added are:

1. A sophisticated interactive graphic input processor allowing for direct entry of a building's geometric characteristics.

2. Multizone modeling. The maximum number of zones allowed is yet to be determined but will be at least 10.

3. Improved models for wall conduction, solar gain distribution within spaces, and infiltration.

4. Sizing and modeling of HVAC equipment.

5. Graphic display of output.

These improvements will strengthen the weak areas of CALPAS3 identified in your report. CALPAS4 is targetted for release in the summer of 1985.

Also, as you point out, BSG now has hourly CALPAS3 weather data available for 12 major Canadian cities and will soon have another 25.

Anyone interested in CALPAS3 or CALPAS4 should contact Maggie Boyce at Berkeley Solar Group.

Sincerely,

Charles S. Barnaby

Charles S. Barnaby
Vice President

Canada Mortgage and Housing Corporation
Société canadienne d'hypothèques et de logement

National Office
682 Montreal Road
Ottawa, Ontario
K1A 0P7

Bureau National
682 chemin Montréal
Ottawa (Ontario)
K1A 0P7

March 27, 1985

Mr. D. Gray, P.Eng.
Leslie Jones & Associates Inc.
1A - 324 Somerset St. West
Ottawa, Ontario
K2P OJ9

Dear Doug:

RE Report: Computer Programs for Passive Solar Residential Design - February 1985

I would like to compliment you on the comprehensive nature of the comparative information in your report, and thank you for the opportunity to comment on its various features.

- we do not expect the 8087 coprocessor to be a requirement when CMHC2 is released. There will, however, be a requirement that the microcomputer support a UNIX based (QNX) operating system. We will be recommending 512K of memory (and possibly the 8087 coprocessor) to reduce the time required to perform some of the analysis features which were not evaluated (but are noted under 'Program Operation') in your review. (These applications automatically engage the thermal-energy analysis in a repetitive fashion and provide a substantial amount of information which can be used to support the delivery of affordable energy-sensitive low-rise housing).

- the program (algorithms) is written in C, a machine language, so changes by users would not be possible. However, changes to the performance and cost data-files, and the many tables used to support the analysis, are possible.

- Accuracy should not be expressed only as a percentage but also should include the absolute value of the error. Although this value is normally small, we did find an error in the formatting of weather data in the program which probably accounts for some of the deviation noted in the spring and fall months.

- draft documentation for program users and for those interested in evaluating the thermal analysis process are now available.

.../2

Canada

- although not clear from your report any orientation of the house (front, back, left, right side) is possible.

- we wish to note that air-to-air heat exchangers, air and water source heat pumps and popular domestic water heaters can be modelled and the peak heating load for the unit is produced (not as noted in tables 4.1 & 4.7).

- there appears to be an inconsistency between page 33 where you note that 'CMHC2 had the shortest calculation time of all the programs tested' and Table 4.9 in which the output analysis times noted is 15 minutes, and many have 10 minutes. If this table is intended to reflect the value and comprehensiveness of the reports, this should be so stated. Incidently, the reports normally are available within 20 seconds if a simple analysis (all except Modes 4 & 5) is being performed.

- re Table 4.1: weather data for sixty (60) sites will be included with the system. These sites were selected from, and correlated with, 240 centres, which represent the solar intensity, winter design temperature, and monthly mean temperature variables for all Canadian locations.

We note that all programs appear to overestimate the consumption of the Alberta Test Hut, Passive Solar Module with a glass-to-floor ratio of 0.24. In addition to the reasons noted in section 4 of the report, the loss through glazed areas may be generally overestimated due to the temperature differential across the glass being somewhat less than the inside-to-outside difference as measured by the instrumentation if the sensors were not directly adjacent to the window. This deviation is normally insignificant but not for an extremely large glass-to-floor ratio such as we have here. The critical factor is that the airfilm which 'resists' heat flow is much greater than conventionally assumed. Generally values are derived from ASHRAE which are based on "... a surface-air temperature difference of 10 degrees F and for surface temperature of 70 F". It is submitted, however, that the best measure of consumption would be that predicted by one of the programs, and not the value measured in the field. This suggestion is made because the predicted value would tend to compensate for occupant discomfort associated with the additional radiation and convection exchanges through the glazed areas.

Again, many thanks for the opportunity to comment on your findings.

Yours truly,

Wayne Webster

Wayne Webster Research Division

January 25, 1985

Mr. Doug Gray
Leslie Jones & Associates Inc.
1A-324 Somerset Street West
Ottawa, Ontario
K2P 0J9

Dear Doug:

Further to our recent telephone conversation, ENERPASS Version 2.0 will be available on the IBM-PC by mid-February. The cost is $350.00 which includes the program, manual and weather data for two cities. The new version addresses most of the criticisms you had of Version 1.1. New features include a humidity model, latest NRC infiltration and basement models and improved ease of use.

Yours truly,

Enermodal Engineering Limited

per Stephen C. Carpenter

SCC/eae

Beckman, Duffie & Associates
4406 Fox Bluff Road
MIDDLETON, WISCONSIN 53562

March 6, 1985

Mr Douglas B. Gray
Leslie Jones & Associates INC.
1A-324 Somerset Street West
Ottawa, Ontario, Canada

Dear Mr. Gray:

This is in response to your request for comments on the draft of the report "Computer Programs for Passive Solar Residential Design." I have looked over the report, and in particular the sections dealing with our F-LOAD program.

In general, I found the report to be a fair assessment of our program. The benefits and deficiencies were correctly noted. We did not see anything major that should be corrected. Hopefully, the report will be a useful document for a practitioneer interested in selecting a building energy analysis program

I hope that these comments are useful.

Sincerely

John W. Mitchell
F-Chart Software

Comments on "Computer Progams for Passive Solar Residential Design"

by Solarsoft Inc.

Having finished reading your report on our SUNPAS/SUNOP program, I feel a few points need to be clarified. Perhaps the most important point is that the program is based primarily on the 'variable based degree day' methodology, not the SLR method, as stated in the review. This is quite significant in light of some of the later comments made which do not reflect an understanding of the reason both methodologies are represented in the program. Having both methods makes it possible for SUNPAS to analyze heavy mass traditional 'solar' buildings (where heating loads are the only consideration), plus buildings (or sunspaces) which do not conform to the passive solar 'types' defined in the Los Alamos Passive Design Handbook. With the variable based degree day method, cooling and heating loads are calculated based on the thermal mass and glazing characteristics defined by the user. With this method (characterized by at least one 'SL' type), effective indoor temperature for two 12 hour periods (day/night) are calculated, and internal gains for each of these periods can be defined by the user/analyst.

Also worthy of note is the fact that the user is able to allow for the venting of excess heat by using the cooling thermostat setpoints option (in conjunction with adequate vent area and an outside temperature that is lower than the cooling setpoint); and that below grade surfaces can have specified insulation levels for calculating below ground heat losses.

A significant advantage in using SUNPAS which deserves to be stressed in your report is the extremely fast run times (30 seconds to 3 minutes depending on machine and building type) - much faster than for any of the simulation-based programs. This factor can be quite important for the professional wishing to optimize his use of time. The speed of SUNPAS makes it possible to run parametric studies in a very reasonable amount of time.

Points brought up in the report which I feel were somewhat misleading include;

- That the copy protection system used by the program requires frequent disk swapping - in fact, during normal progam usage, the user is required to swap disks only when starting-up and thereafter only when making the transition between SUNPAS and either SUNOP or the Climate and 'Calculation Aids' sections of the program package - disks are not be switched when moving between the input and analysis modes. This system of copy-protection also makes it possible for the program to be used simultaneously by multiple users, as in a university teaching situation.
- The comment was also made that all climate data must be entered by the user - this is not normally the case; the program is supplied with 2 or 3 appropriate climates on-disk

when purchased. The fact that new climates can be entered or existing climate files modified should be viewed as a benefit, not an inconvenience.
- The report implied that no default values were given in the building input section - to the contrary, default values are present wherever they are appropriate, and comments are made about them in the User's Manual.
- The comments made regarding making back-up copies of disks were well founded at the time the review copy was received by your organization; the problems have since been corrected.
- It was remarked in the report that the procedure for editing an existing file is 'inconsistent with the data entry procedure'. In fact, the procedure is identical to the normal data entry procedure - with the added benefit of being able to move around the screen by using the arrow keys (or, on the Apple II, the I, J, M, and K keys) before entering the editing mode - perhaps the reviewer did not read the 'Standard Program Procedures' section of the User's Manual.
- Comments about the documentation seem to revolve around the organization of the information rather than the content, it appears that when the User's Manual was updated (the original version received by the NRC was a pre-release version), the new sections of the manual were not inserted into the Solarsoft binder (which does have dividers). It should also be noted that the documentation uses margin notes for quick reference, and has a table of contents for each major section of the program, including the Appendices.
- The evaluators of the program claimed to have encountered problems while running the program. The problems reported to Solarsoft were solved and Solarsoft was not made aware of any other remaining problems. User support is maintained by phone or letter and no known problem persists in the current version of SUNPAS.
- SUNPAS/SUNOP version 4.0 is currently priced at $625.

It was interesting to note that on your graph of confidence range for all the programs reviewed, that SUNPAS was the only program which had all its results within the limits of 'confidence'.

We would like to thank you for this opportunity to comment on your report. We appreciate your professional approach and recognize your effort to fairly evaluate all programs submitted. Solarsoft has learned from our participation and looks forward to seeing the final product of your energies.

Sincerely,

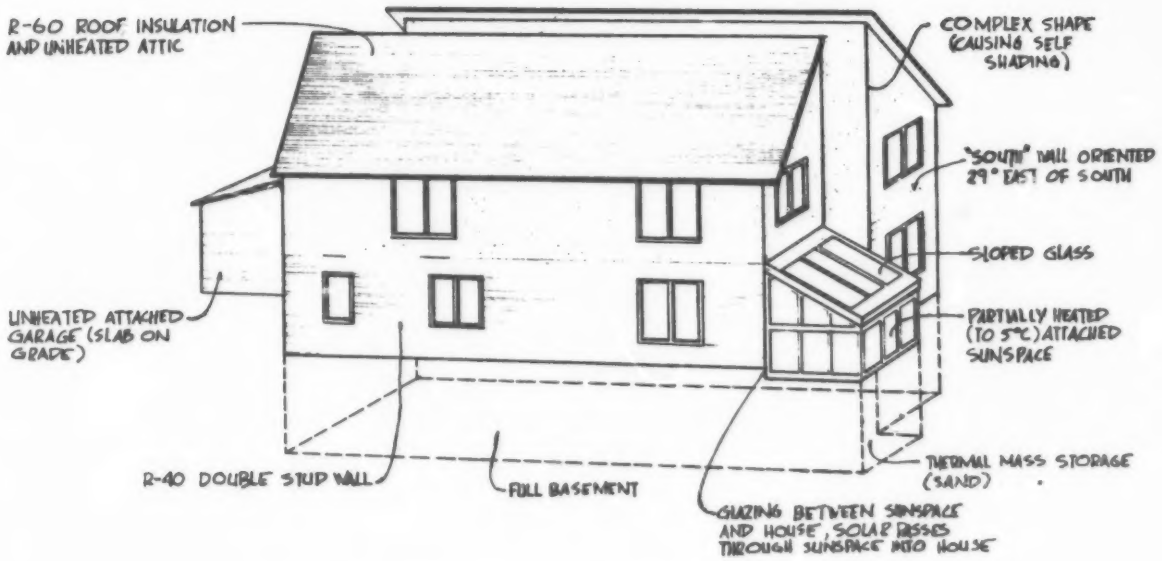
Bill Ashton

Bill Ashton
President, Solarsoft, Inc.

APPENDIX D
AXONOMETRIC OF HOUSE USED IN TESTING

COMPLEX HOUSE DESIGN

OTHER FEATURES
- ELECTRIC BASEBOARD HEATING
- NIGHT SETBACK
- OUTSIDE AIR VENTILATION


R-60 ROOF INSULATION AND UNHEATED ATTIC
COMPLEX SHAPE (CAUSING SELF SHADING)
"SOUTH" WALL ORIENTED 29° EAST OF SOUTH
SLOPED GLASS
PARTIALLY HEATED (TO 5°C) ATTACHED SUNSPACE
UNHEATED ATTACHED GARAGE (SLAB ON GRADE)
THERMAL MASS STORAGE (SAND)
R-40 DOUBLE STUD WALL
FULL BASEMENT
GLAZING BETWEEN SUNSPACE AND HOUSE, SOLAR PASSES THROUGH SUNSPACE INTO HOUSE